

Climate Forecasts for Improving Management of Energy And Hydropower Resources in the Western US

How does climate variability affect energy demand and supply?

Do seasonal climate forecasts provide useful skill for the variables that affect the energy system?

What is the affect of predictable climate variability on the energy system?

How can utilities and public sector decisionmakers use this information to opimize system performance?

Climate Forecasts for Improving Management of Energy And Hydropower Resources in the Western US

Support

NOAA and CEC

Partnerships

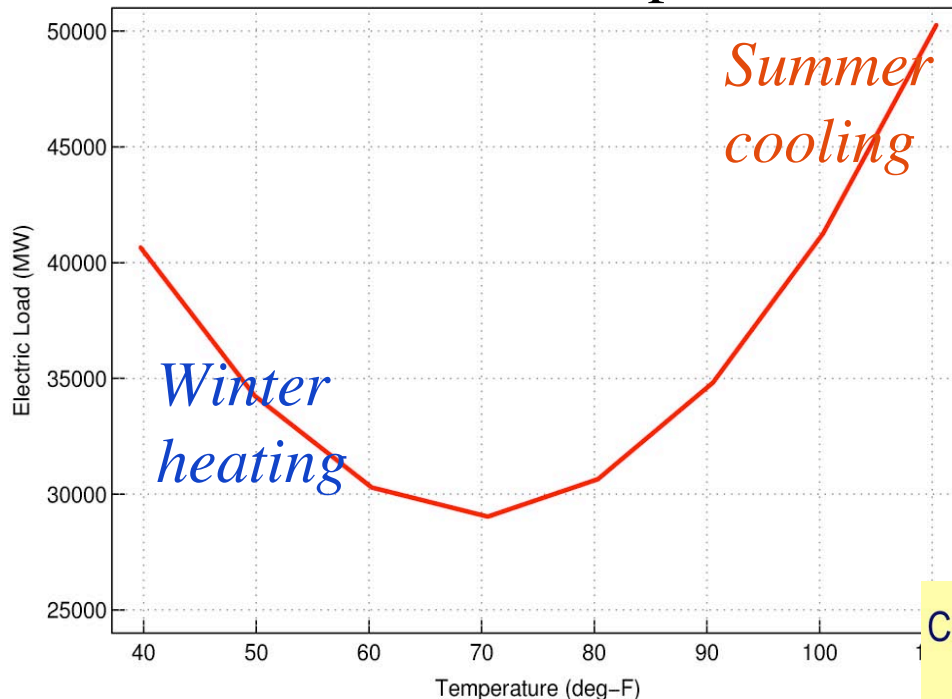
University of Washington

Center for Water and Watershed Studies

Climate Impacts Group

Peak CA Electrical Demand is Driven by Temperature

CA Load vs Temperature

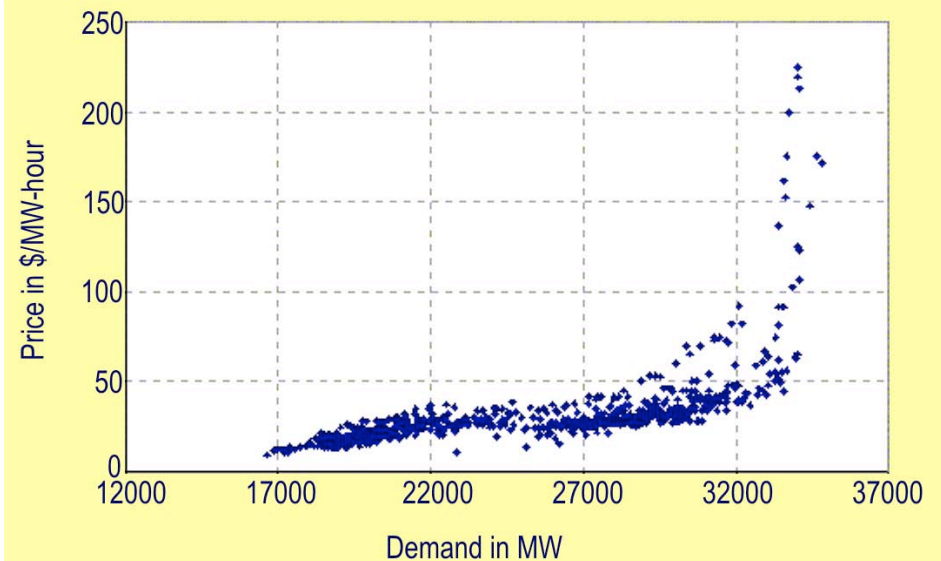


... and it is Expensive:

Demand is relatively inelastic
&

Marginal Costs of peak
production are very high

California day-ahead electricity price vs. demand, August, 1999



Western Wildfire Projects

Decision Calendars

Fire Histories

Fire Climatology

Seasonal Forecasts

Application: Forecasts for Budgeting

Temperature and Forest Wildfire

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Partnerships

CLIMAS

CEFA

Laboratory of Tree-Ring Research

National Interagency Fire Center - Predictive Services

USDA Forest Service

USDI National Park Service, BLM

Decision Calendars for Wildfire Management

When are important management decisions made?

What climate information is used? When?

What climate information could be used? When?

Decision Calendars for Wildfire Management

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What climate information is used? When?

What climate information could be used? When?



Partnerships and Participants

CLIMAS



CLIMAS

National Interagency Fire Center: Predictive Services, NICC

Geographic Coordinating Centers in CA & AZ

Joint Fire Sciences Program

California Firescope

USDA Forest Service and National Park Service:
land management units in California and Arizona
national budget directors



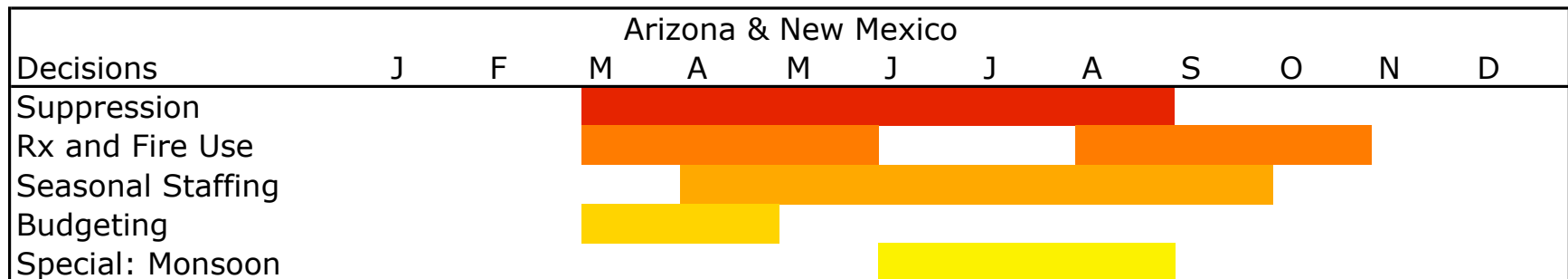
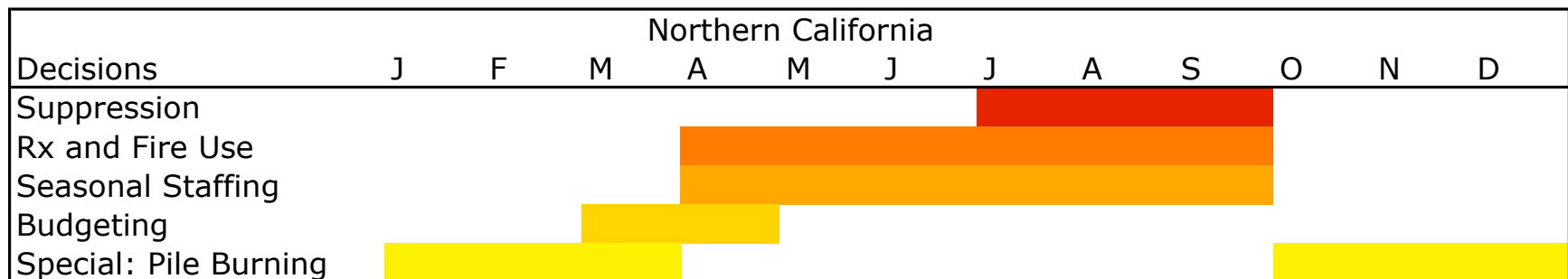
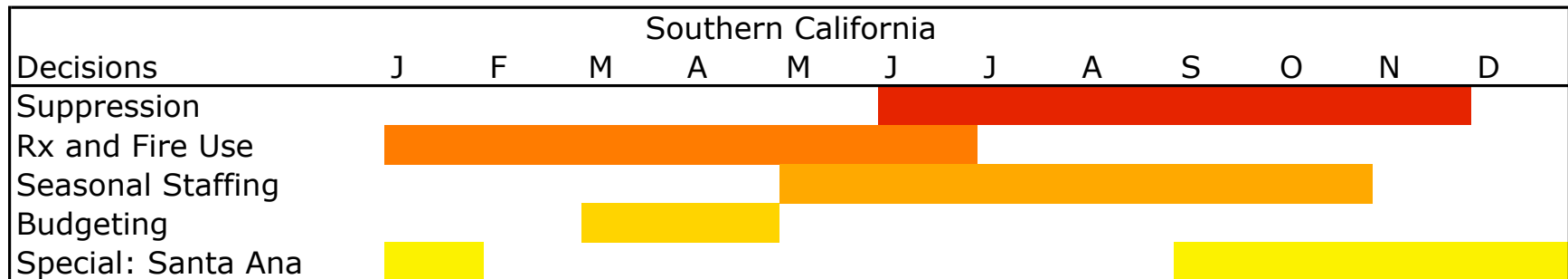
USDA FS



NPS



Decision Calendars for Wildfire Management



Decision Calendars for Wildfire Management

Opportunities

Budget requests and Emergency Funding requests

Preparedness and Presuppression Planning

~ Annual hiring, training and staffing decisions

Mobilization decisions

Fire Management Plans

Obstacles

Two-year budget cycle

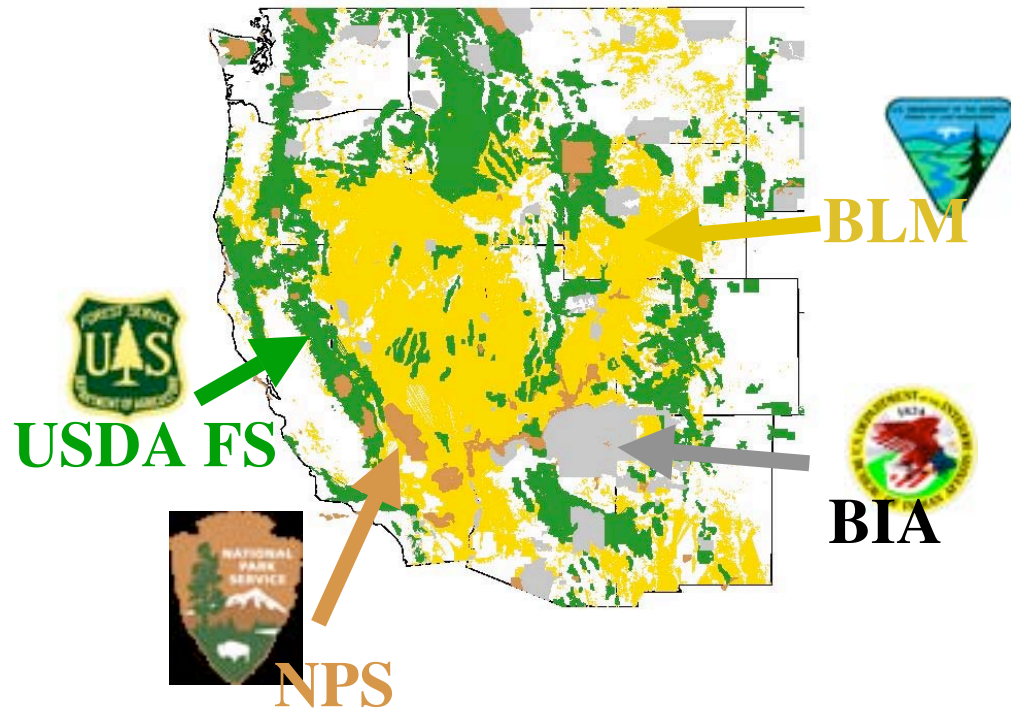
Inflexible authorizing legislation

~ Endangered Species Act

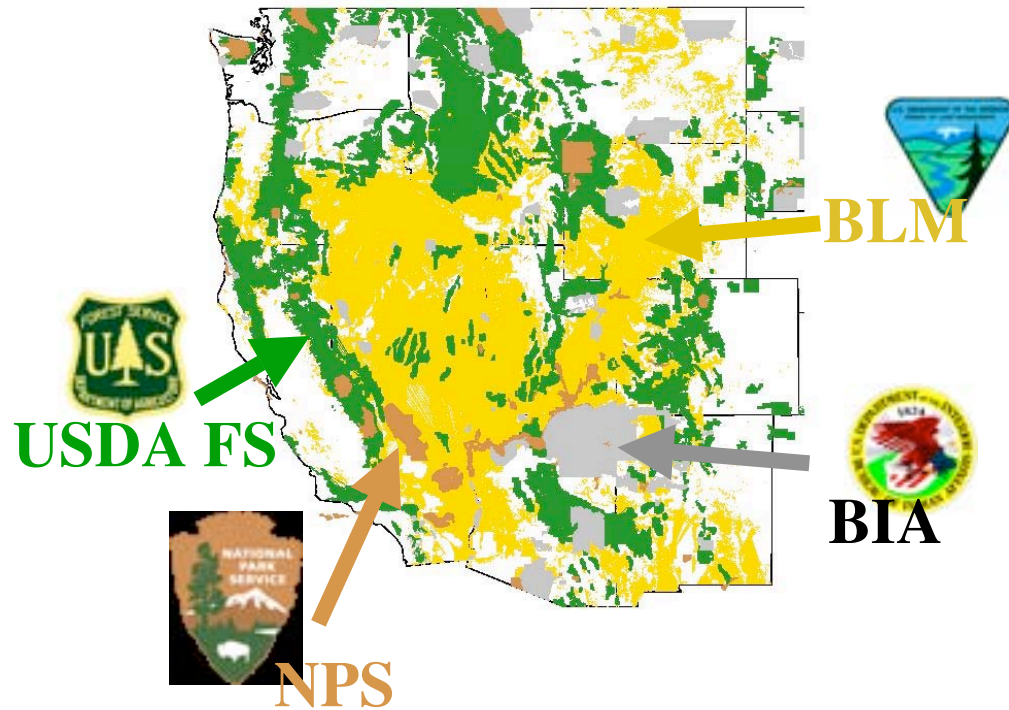
Lack of flexibility in planning processes

Mismatch between decision and forecast time horizons

Federal Agencies Manage Most of the West's Wild Lands



Federal Agencies Manage Most of the West's Fires

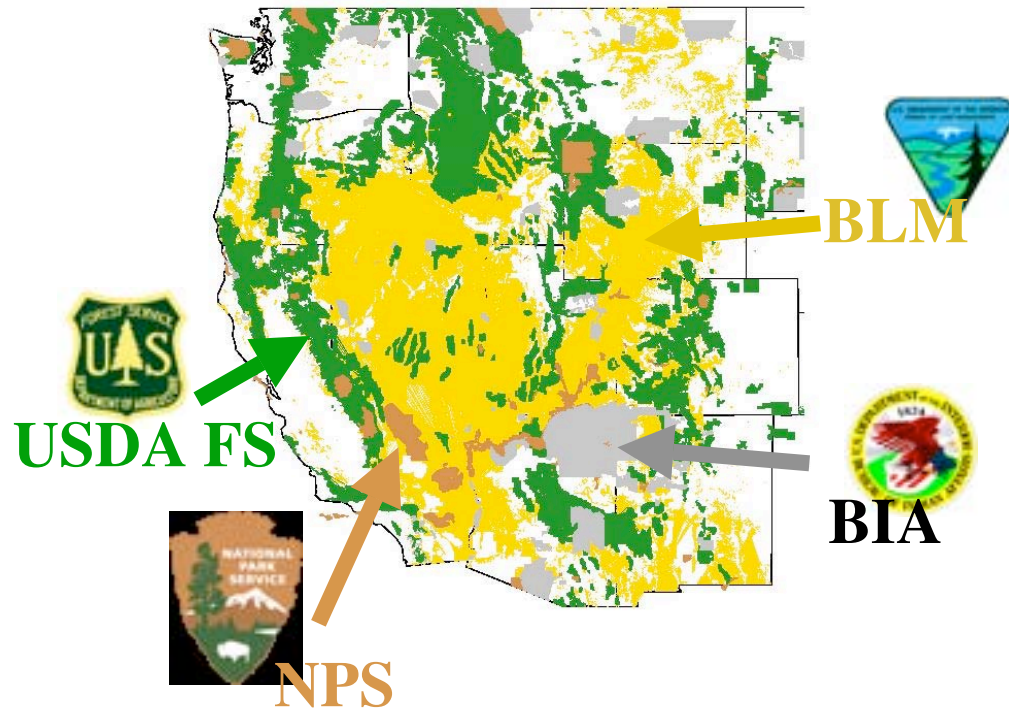


Federal fire suppression expenditures
since 1994 average ~

\$924 million/year



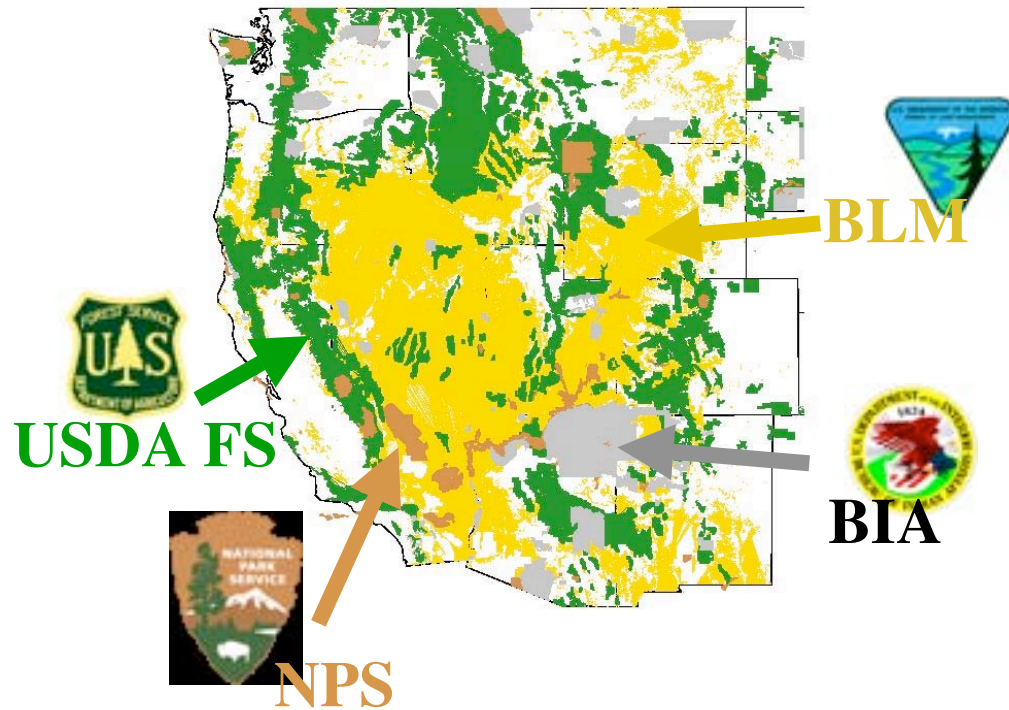
Federal Agencies Collect Most of the West's Fire Data



There is no central repository for fire histories in the US

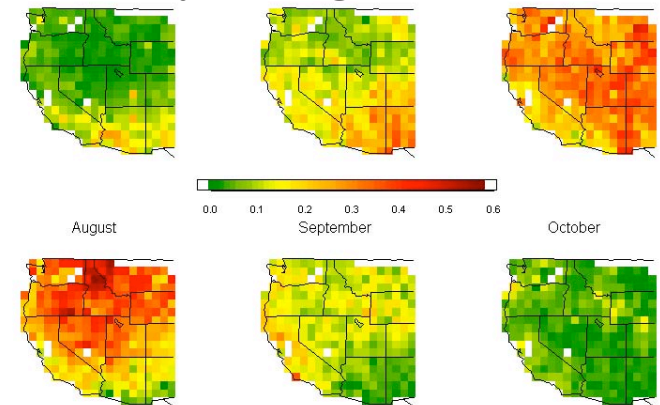
Federal land management in the West facilitates collection of fire histories

Fire Histories for the Western US are a valuable resource

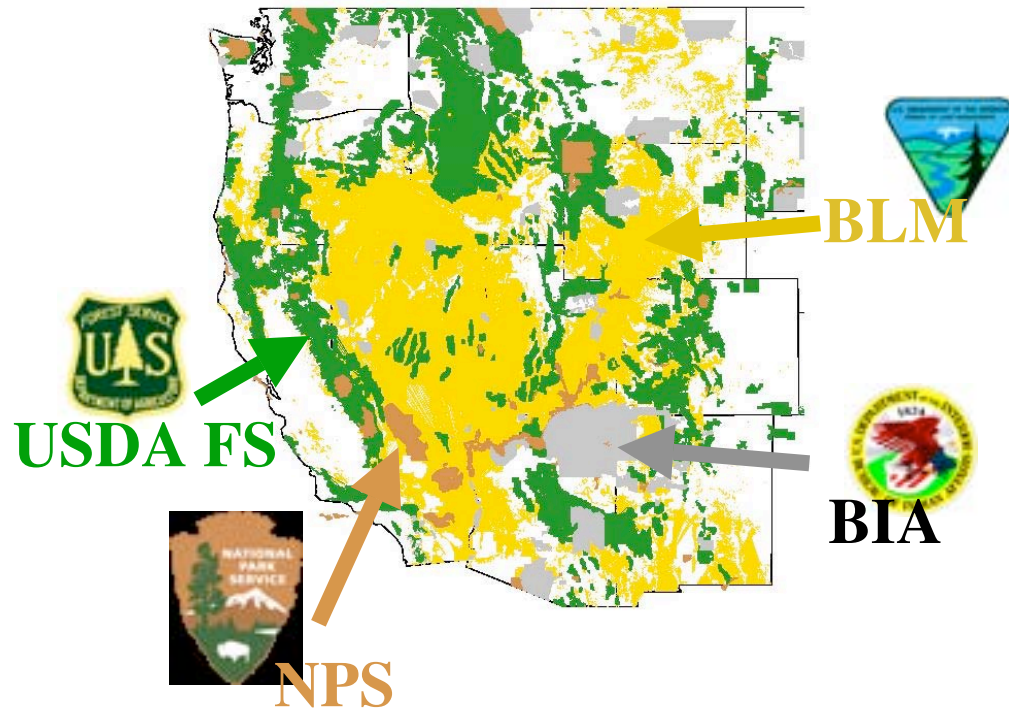


CAP researchers were the first to compile a comprehensive Western fire history for recent decades from land management agency fire records

Seasonal Cycle - Wildfire Ignitions May through October



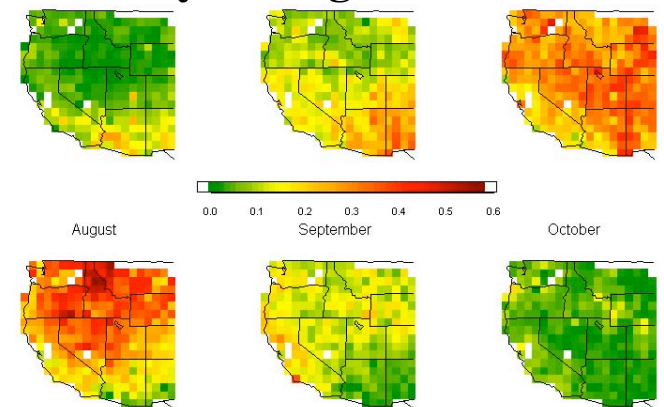
Fire Histories for the Western US are a valuable resource



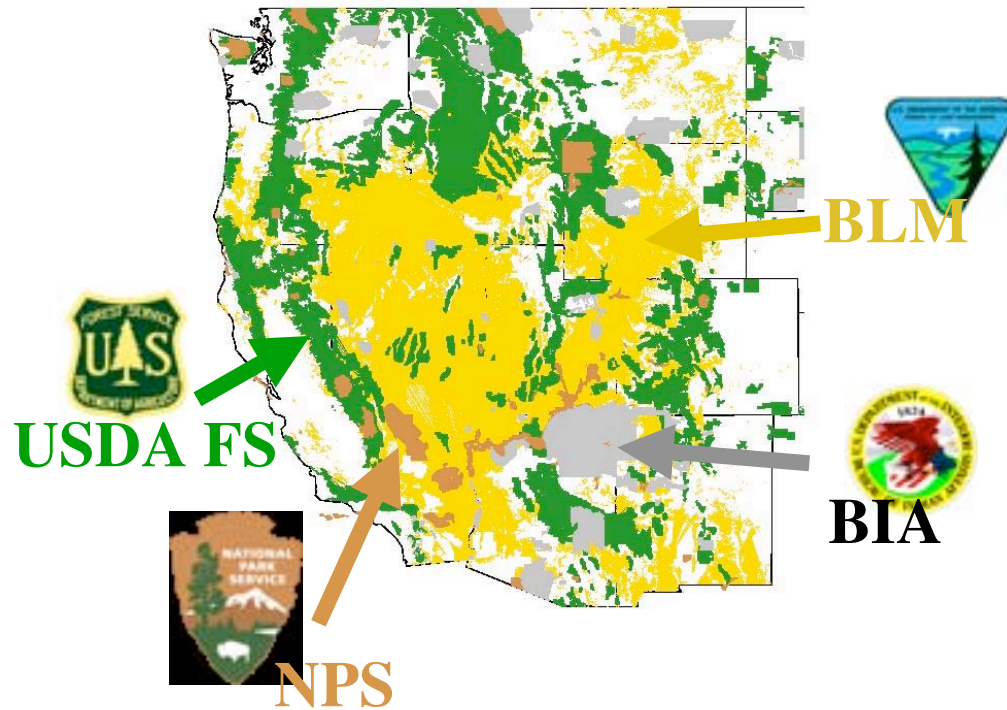
A new western North American large fire history integrates State of California and Canadian large fire histories with Federal fire histories to extend coverage.

Partnership with LTRR to complement to IMPD with a central repository

Seasonal Cycle - Wildfire Ignitions May through October



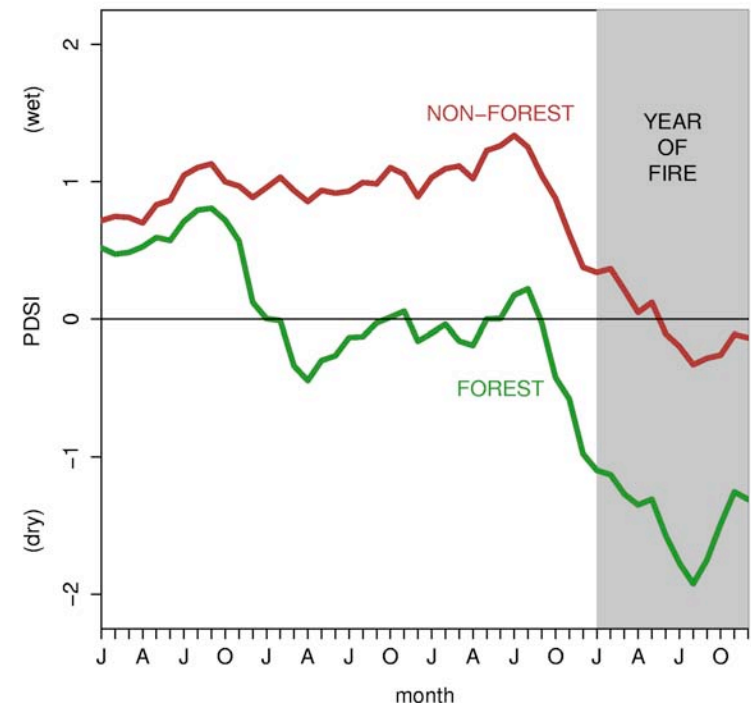
Climate Drives Interannual Variability in Western Wildfire



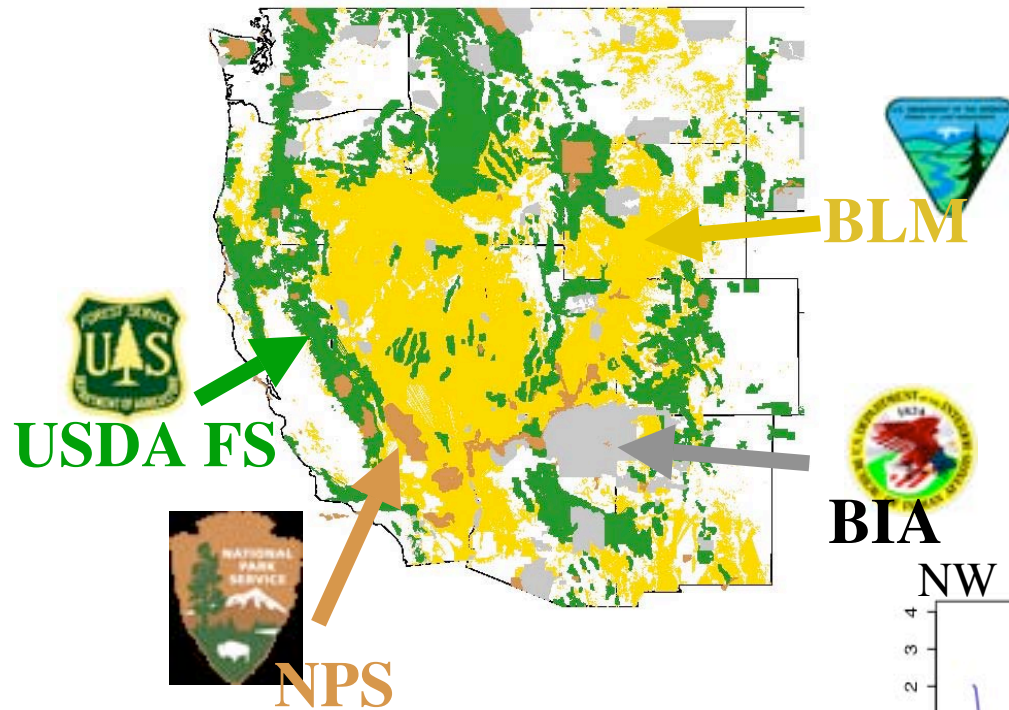
Inter-annual variability in wildfire is strongly related to variability in **Precipitation** and **Temperature**

Antecedent Moisture plays an important role in promoting fuel accumulation.

Composite PDSI
Large **Forest** vs **Shrub & Grass** Fires

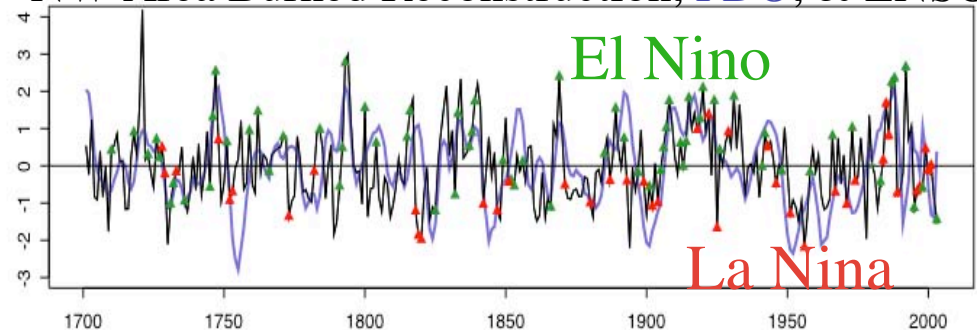


Climate Drives Decadal Variability in Western Wildfire

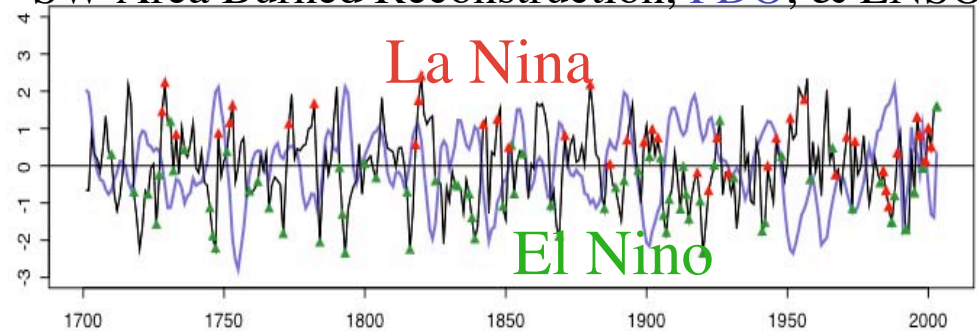


Decadal variability in wildfire reflects the influence of regionally dominant modes of climate variability on Precipitation and Temperature

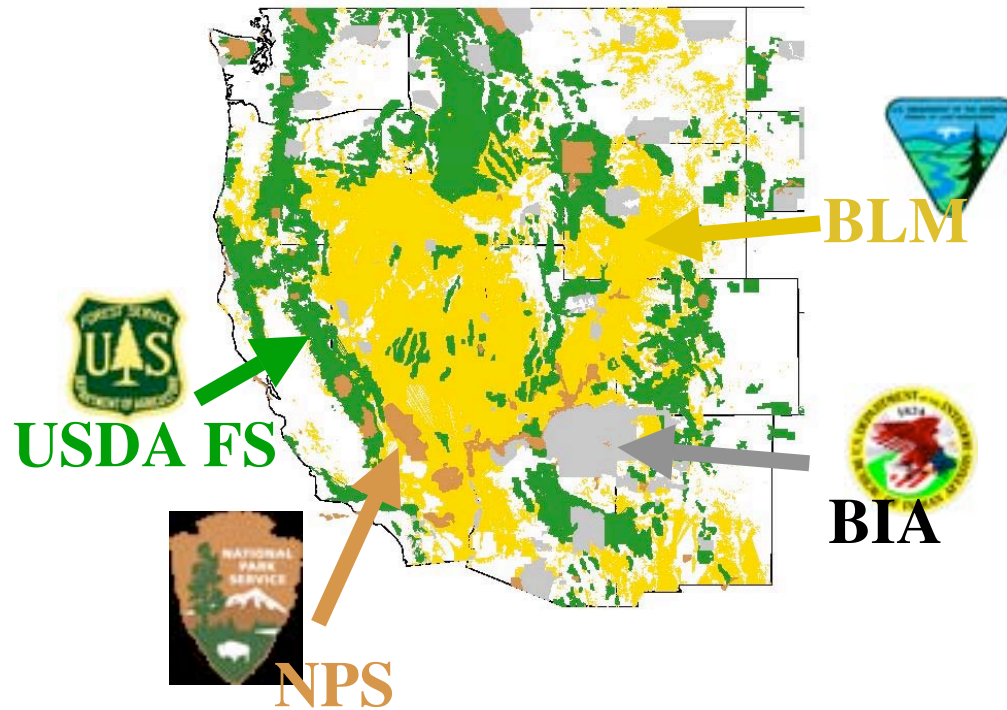
NW Area Burned Reconstruction, PDO, & ENSO



SW Area Burned Reconstruction, PDO, & ENSO



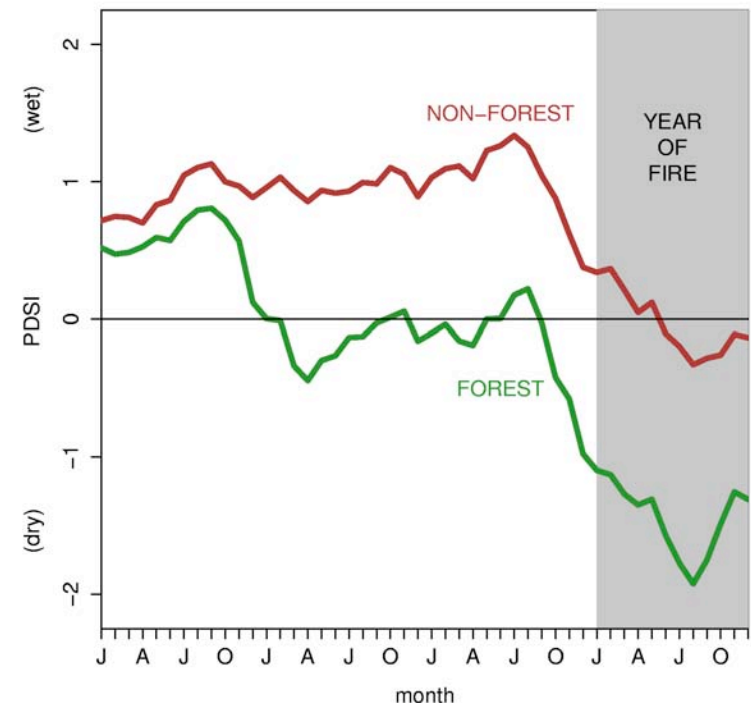
Climate - Wildfire Relationships Enable Seasonal Forecasts



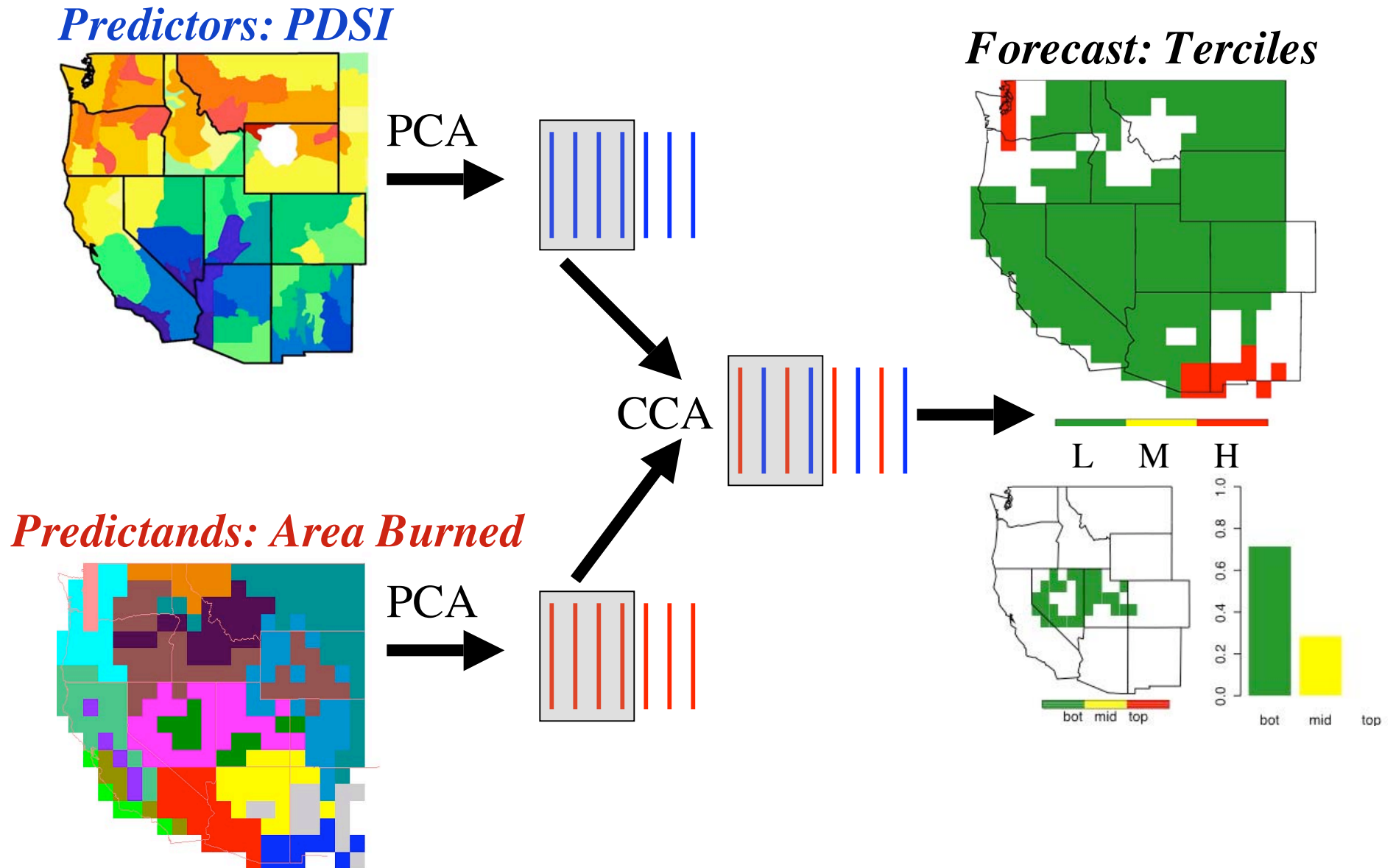
These relationships provide some skill in making **seasonal forecasts** of wildfire area burned

Federal Agency partners use these forecasts for their fire season assessments and budgeting

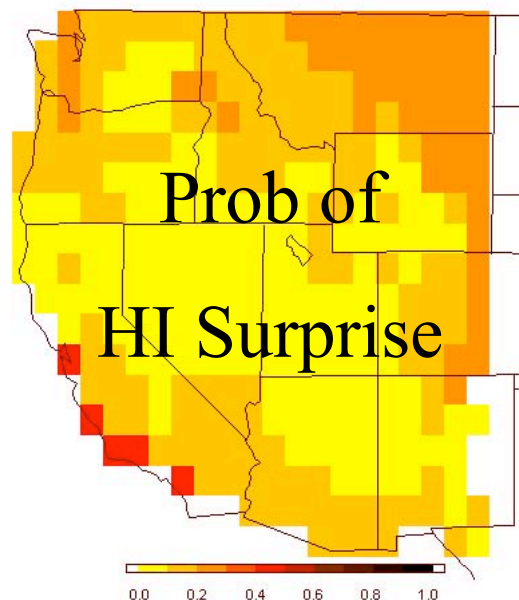
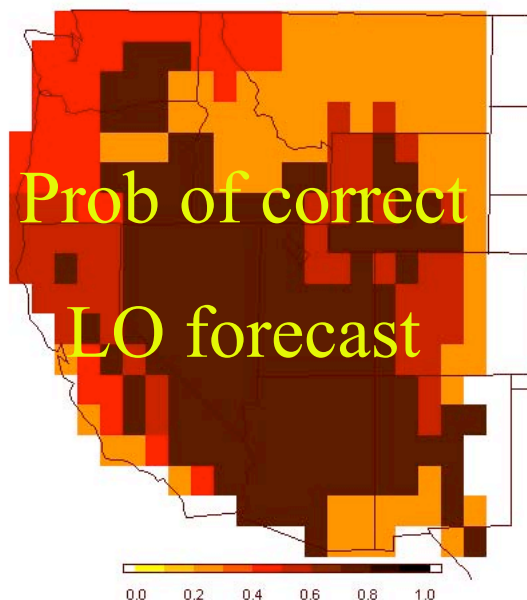
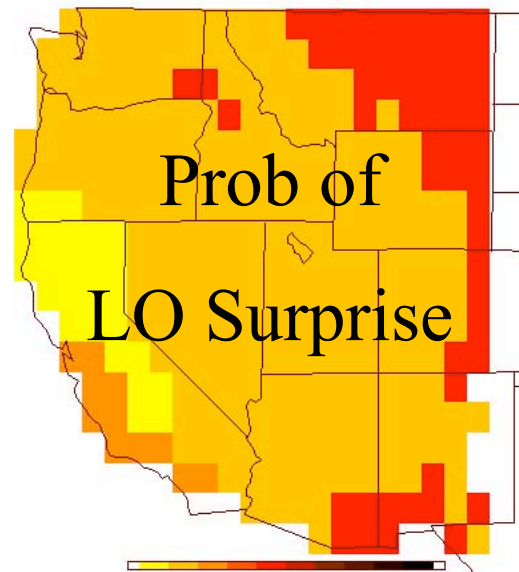
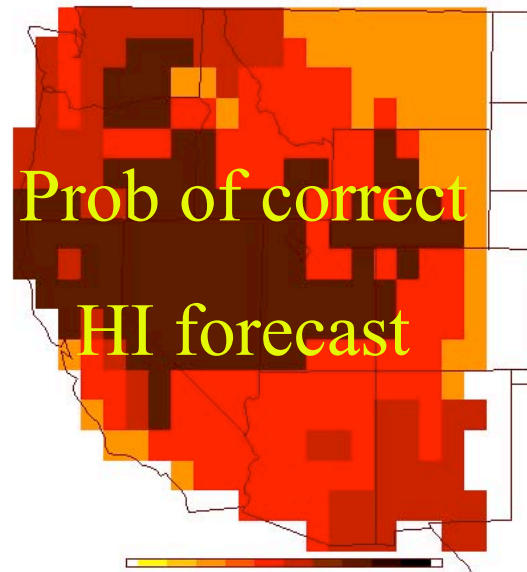
Composite PDSI
Large **Forest** vs **Shrub & Grass** Fires



Seasonal Area Burned Forecasts



Seasonal Area Burned Forecasts

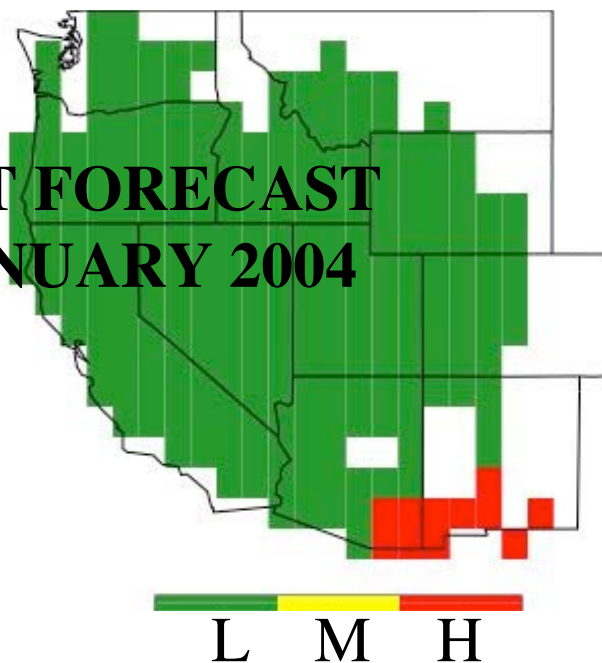


Highest forecast skill is in regions where grasses and herbaceous fuels play an important role in fire ignition and spread

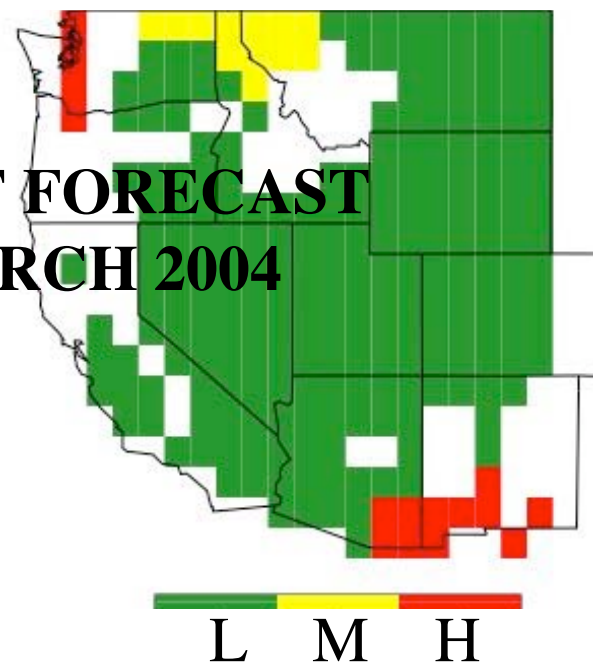
...and where our fire histories are comprehensive

2004 Wildfire Season Terciled Forecasts of Area Burned

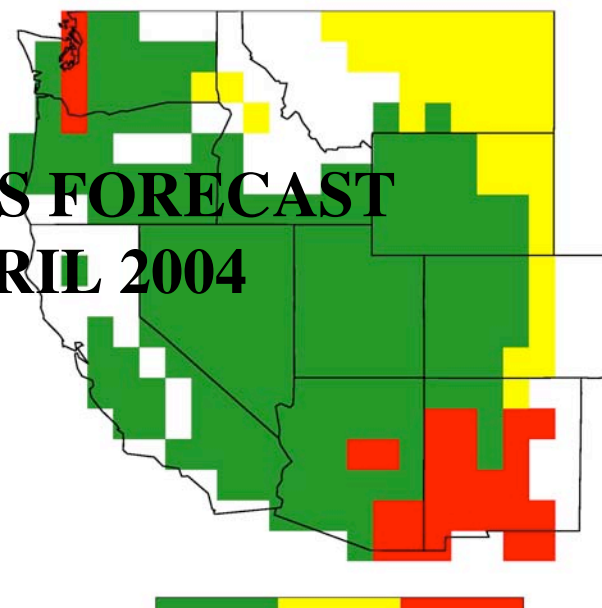
**SST FORECAST
JANUARY 2004**



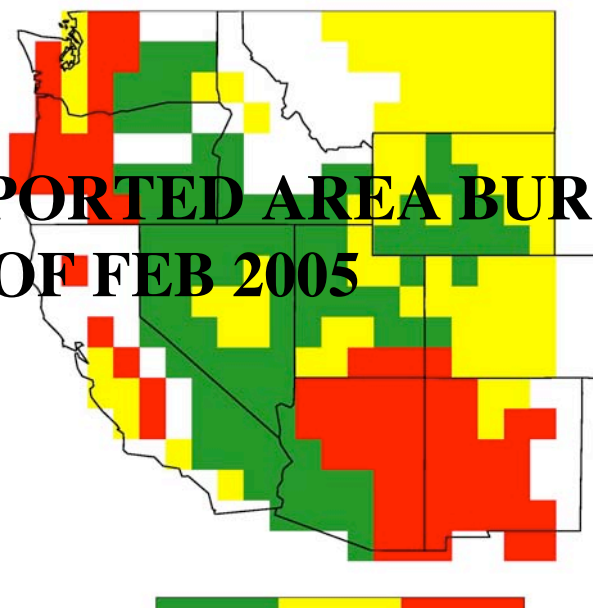
**PST FORECAST
MARCH 2004**



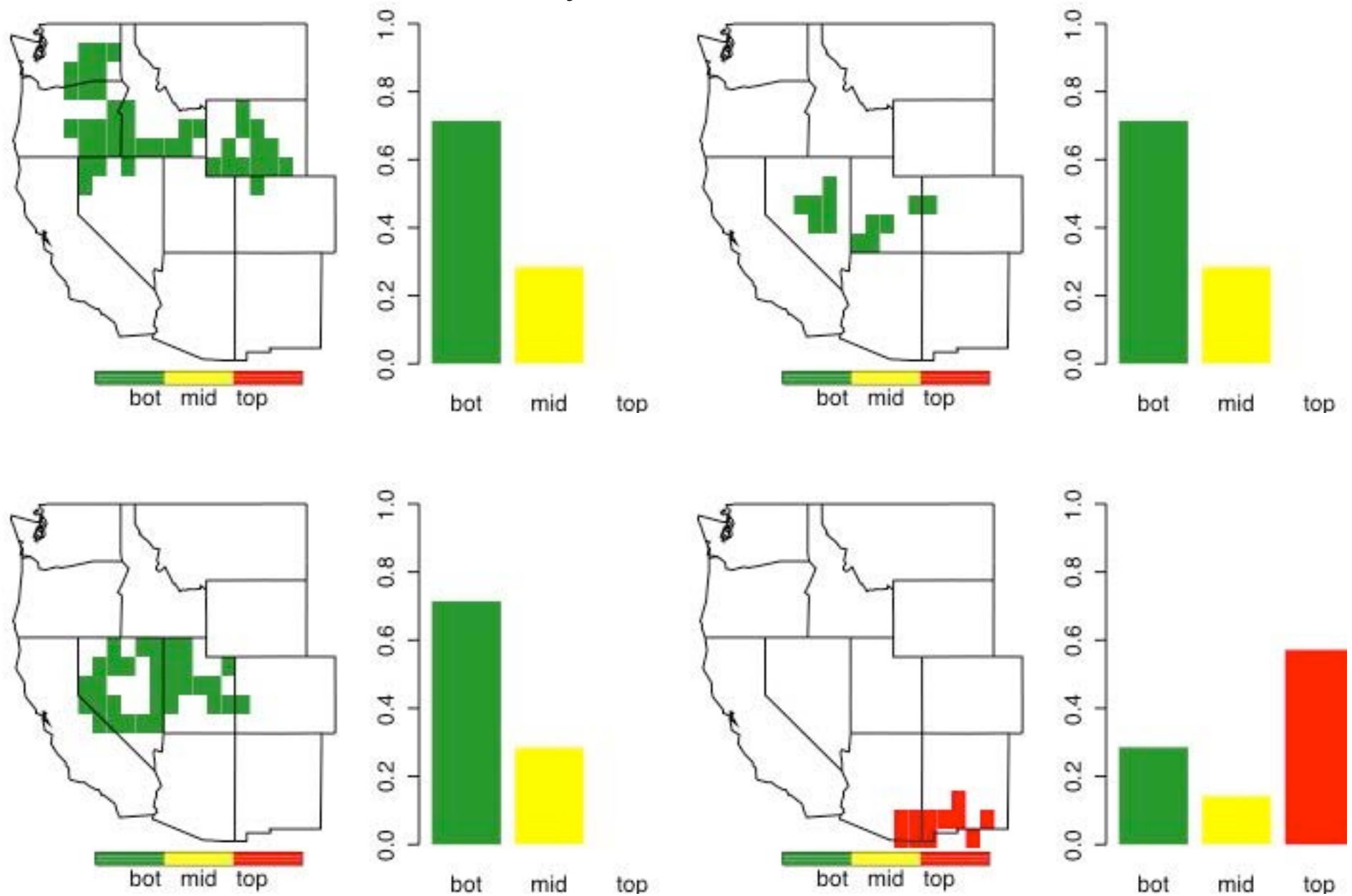
**OBS FORECAST
APRIL 2004**



**REPORTED AREA BURNED
AS OF FEB 2005**



Observed Outcome Probability Conditional on Forecast Tercile



Seasonal Fire Forecast Application

Current: Planning for Forest Service Suppression Expenditures in late winter/early spring prior to the fire season

Project: Can we improve upon 10-year averages for forecasting FS suppression expenditures 9 months in advance?

Partnerships

USDA Forest Service

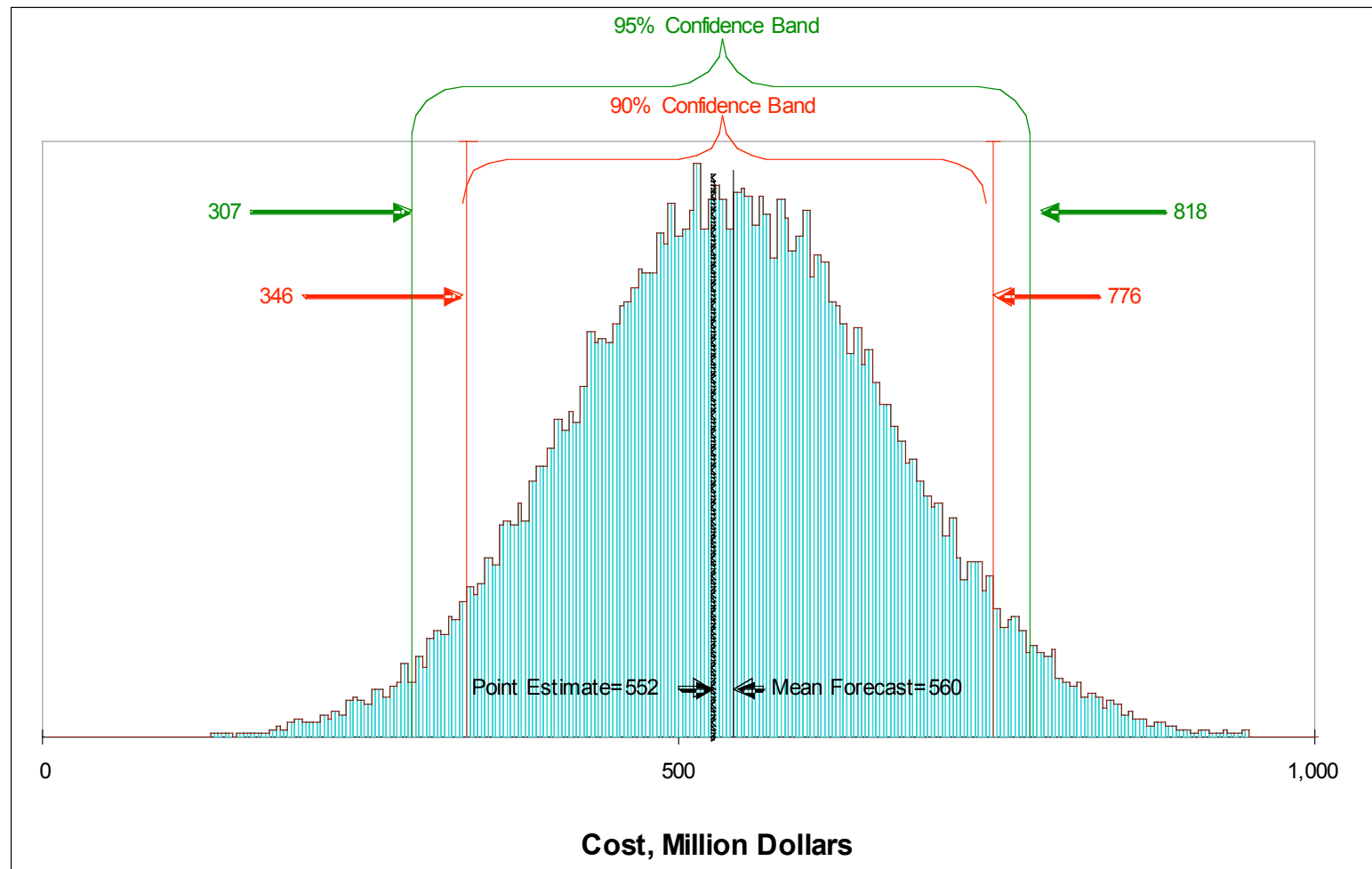
Rocky Mountain Research Station

Forest Economics group in Southern Research Stations Forest Sciences Lab

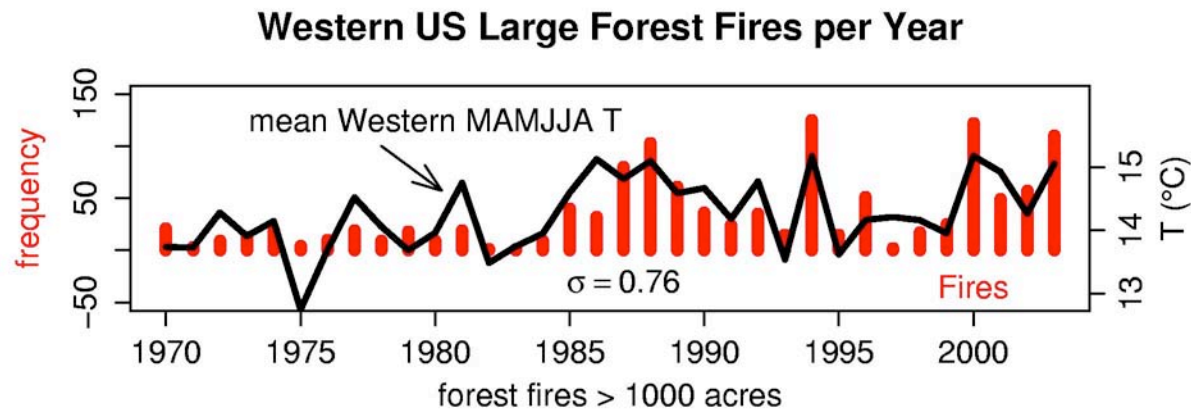
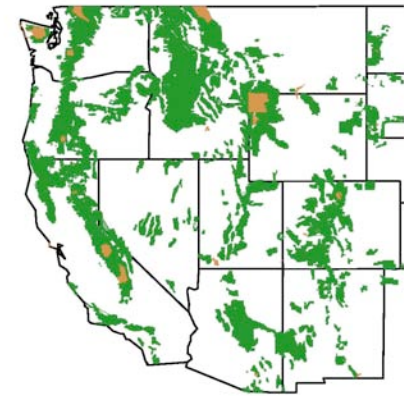
National Interagency Fire Center: Predictive Services

Seasonal Fire Forecast Application

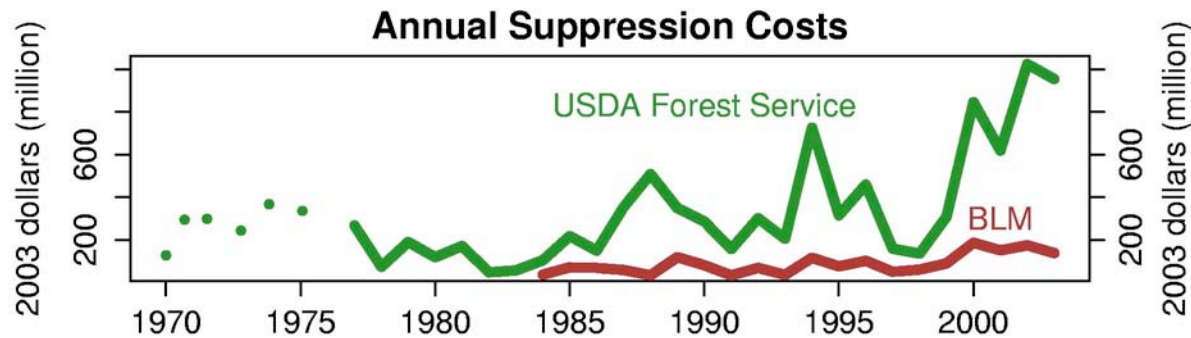
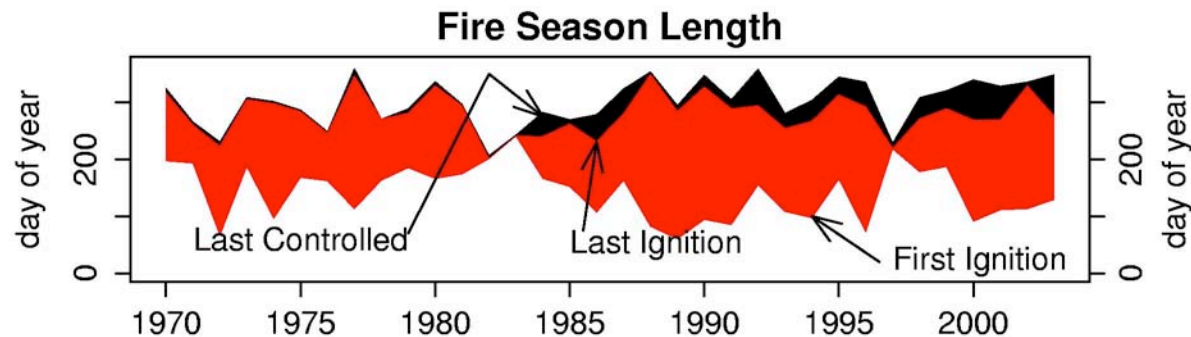
2005 Forest Service “Early Warning” Suppression Cost Forecast and Confidence Bands



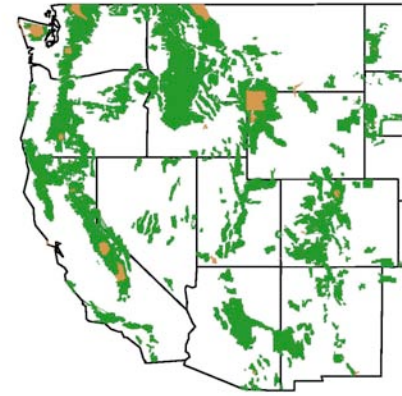
Temperature & Forest Wildfire



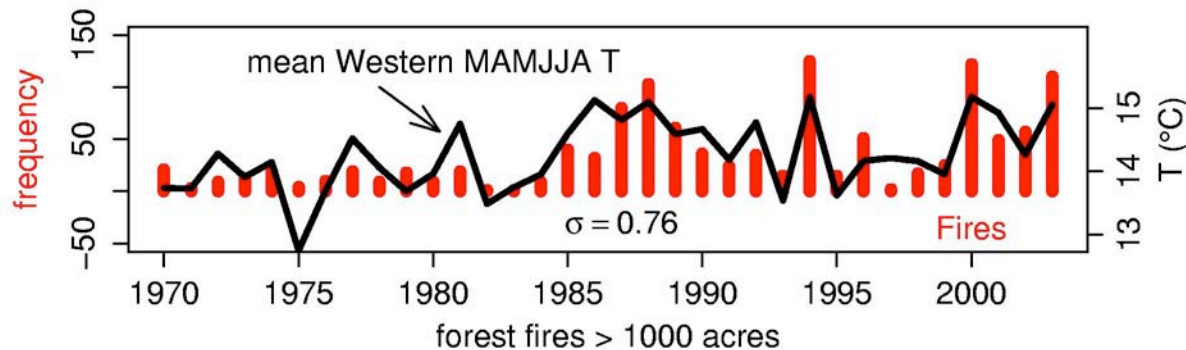
Spring & Summer T
explains > 50% variance
in large wildfires



Temperature & Forest Wildfire

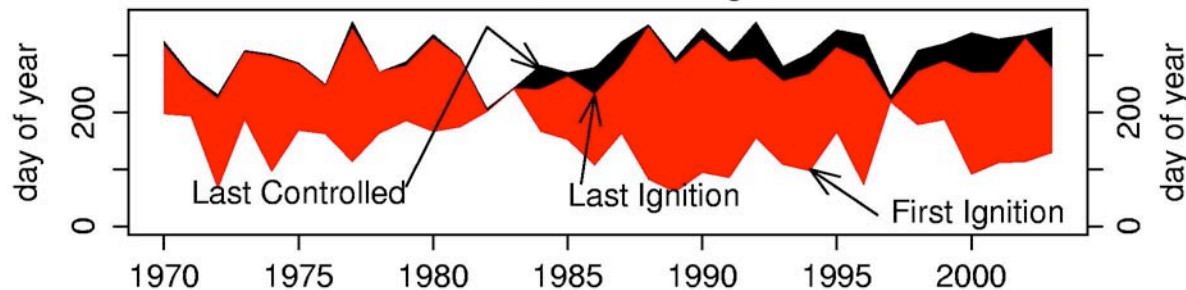


Western US Large Forest Fires per Year



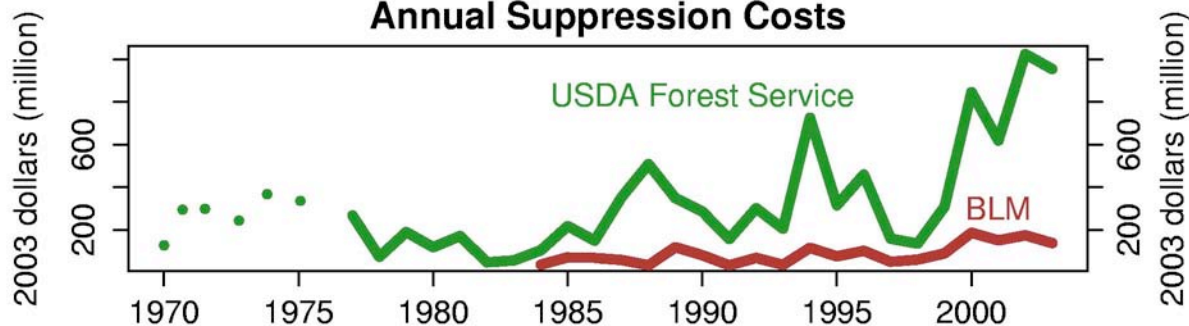
Spring & Summer T explains > 50% variance in large wildfires

Fire Season Length



Fire season is 2 months longer on avg. since 1987.

Annual Suppression Costs

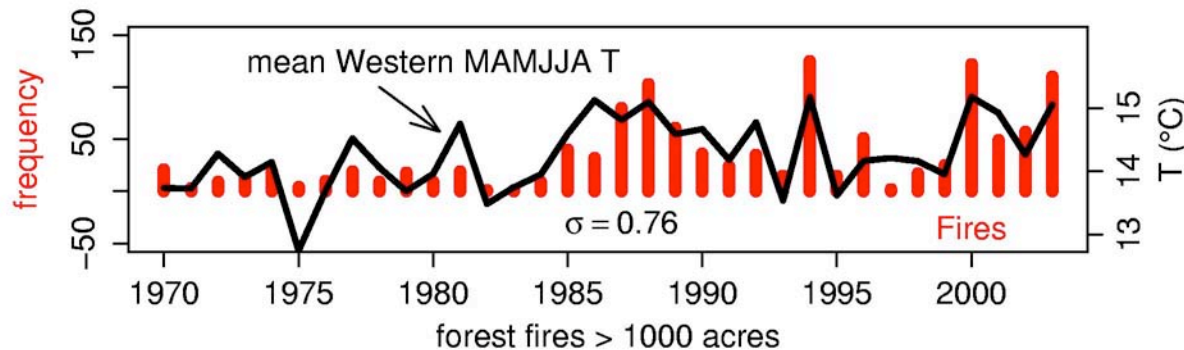


Large fires burn longer: (from < 1 week to > 1 month)

Temperature & Forest Wildfire

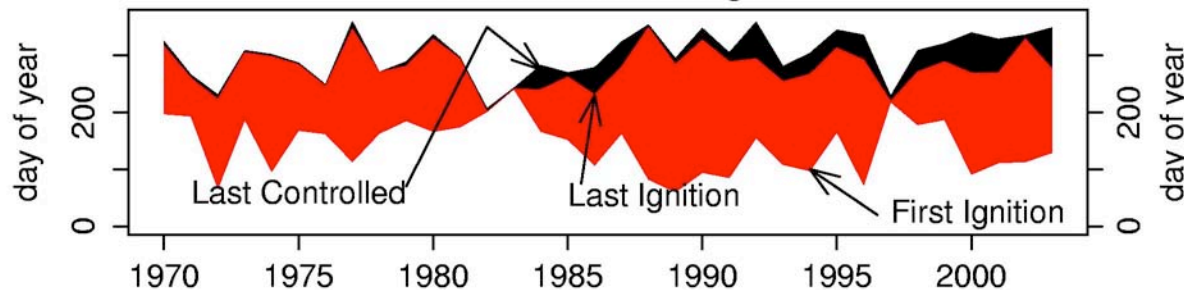


Western US Large Forest Fires per Year



Spring & Summer T explains > 50% variance in large wildfires

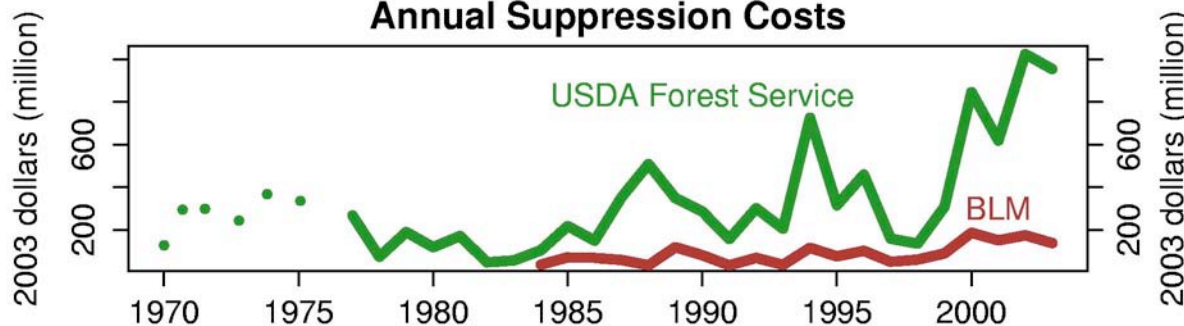
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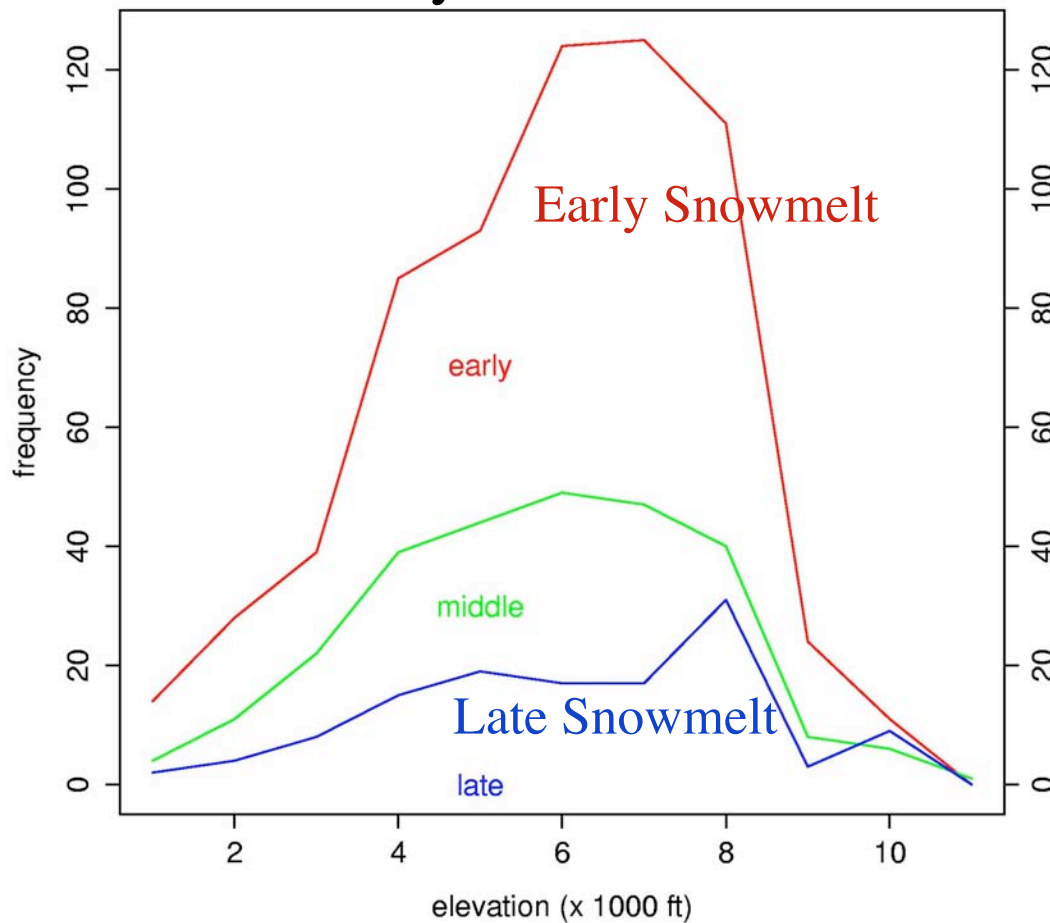
Annual Suppression Costs



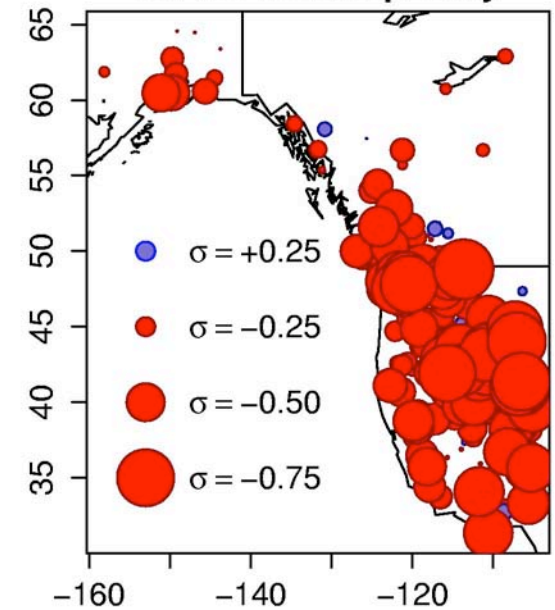
Fire suppression expenditures have increased much more for forest wildfires than for grass- and shrub-land wildfires.

Temperature & Forest Wildfire

Snowmelt Timing & Large Forest Fires By Elevation



Snowmelt Timing Cor. w/ Large Fire Incidence





13 major fires in CA& Mex.

> 300K hectares (750K acres)

24 lives lost

239 injured

4866 structures lost

> \$2 billion in insured losses

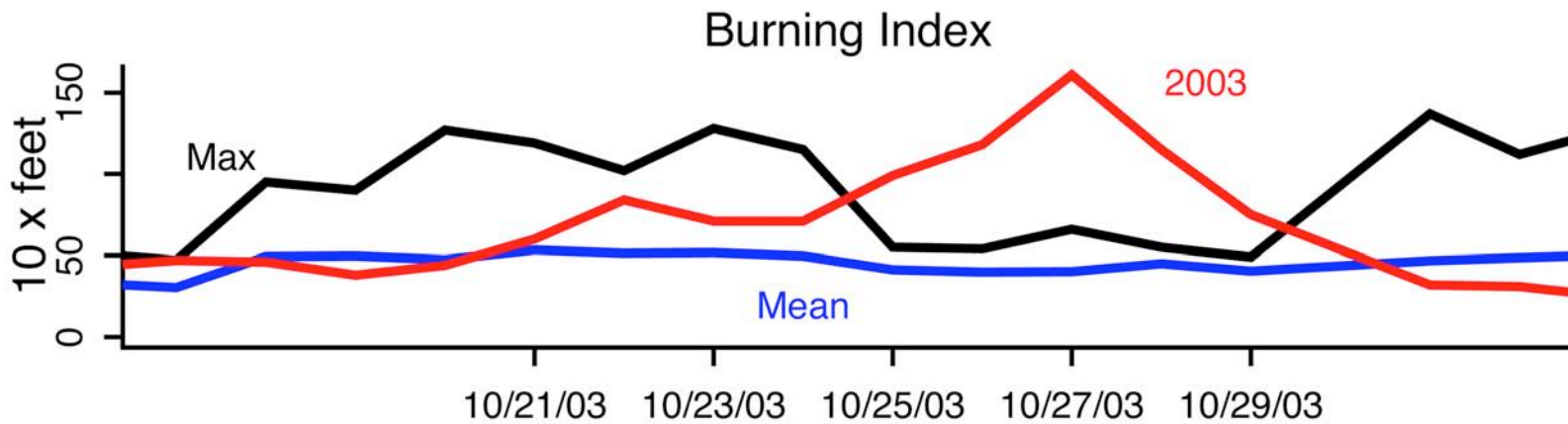
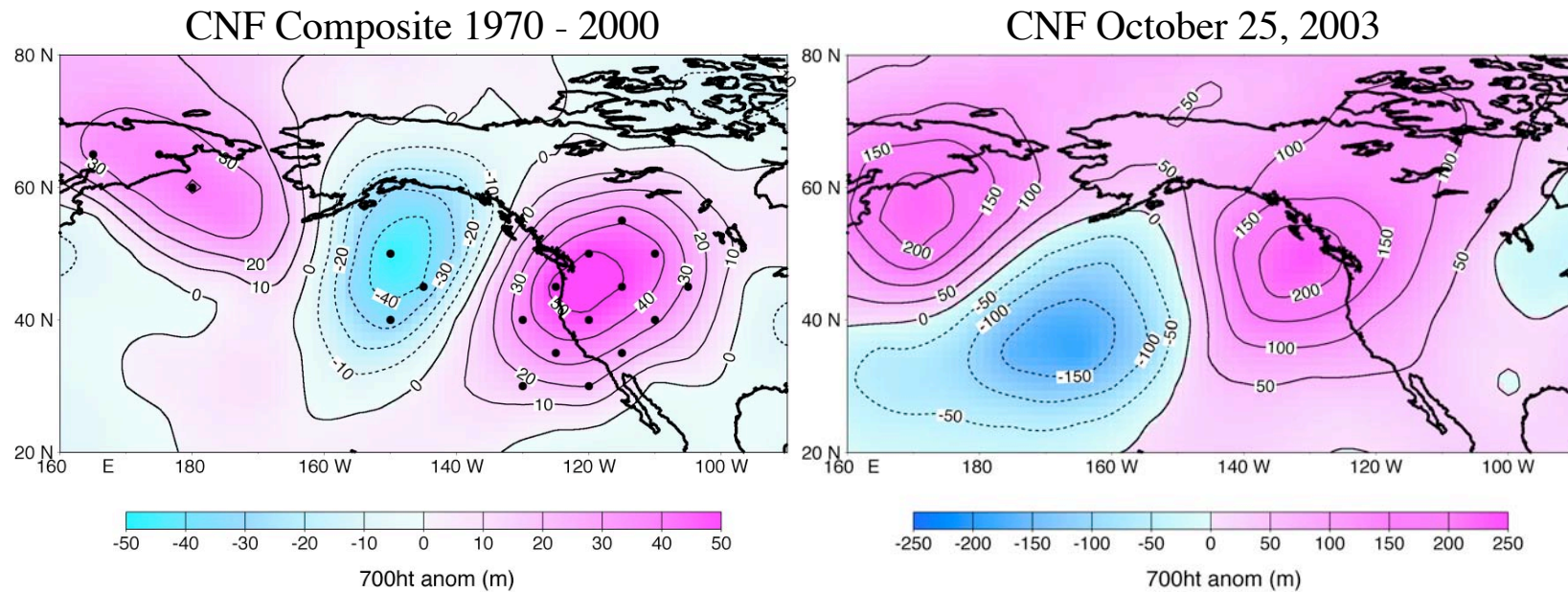
~ \$3.5 billion in total property losses

\$176 million in disaster relief

\$116 million in suppression costs

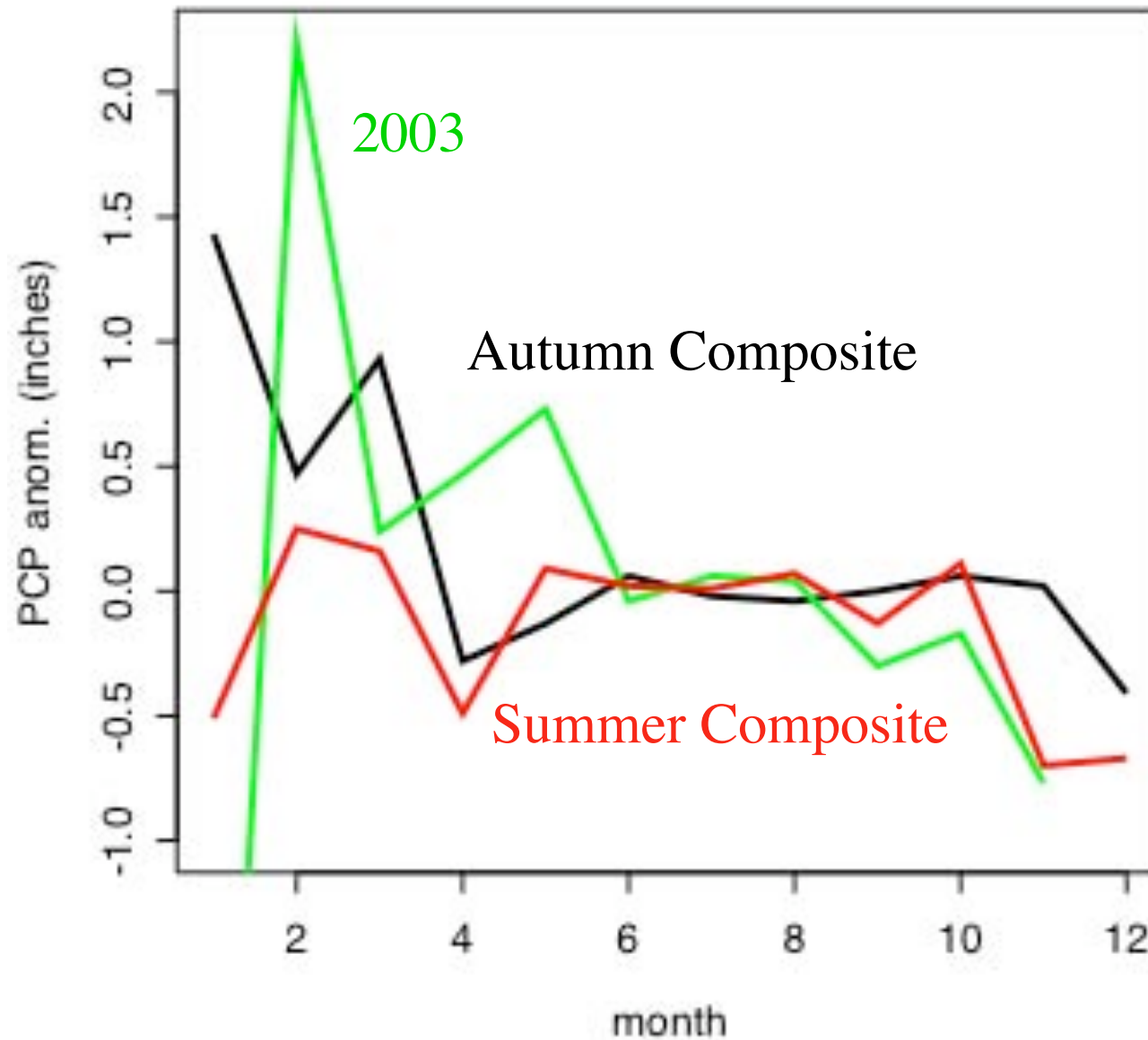
Largest fire (Cedar) and largest fire siege in California history

Santa Ana Winds and Large Southern California Wildfires in Autumn and Winter

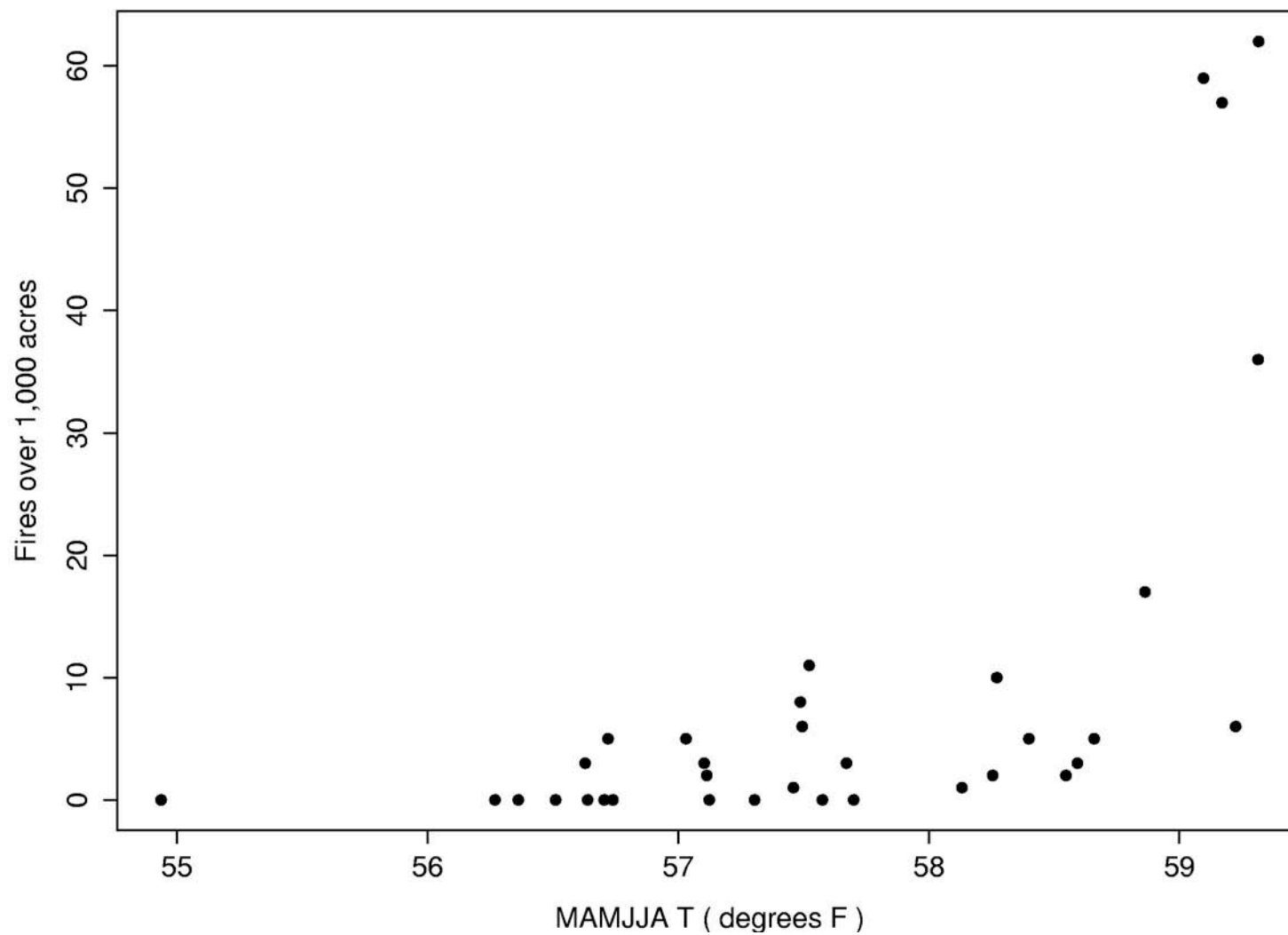


CNF Burning Index, October 2003

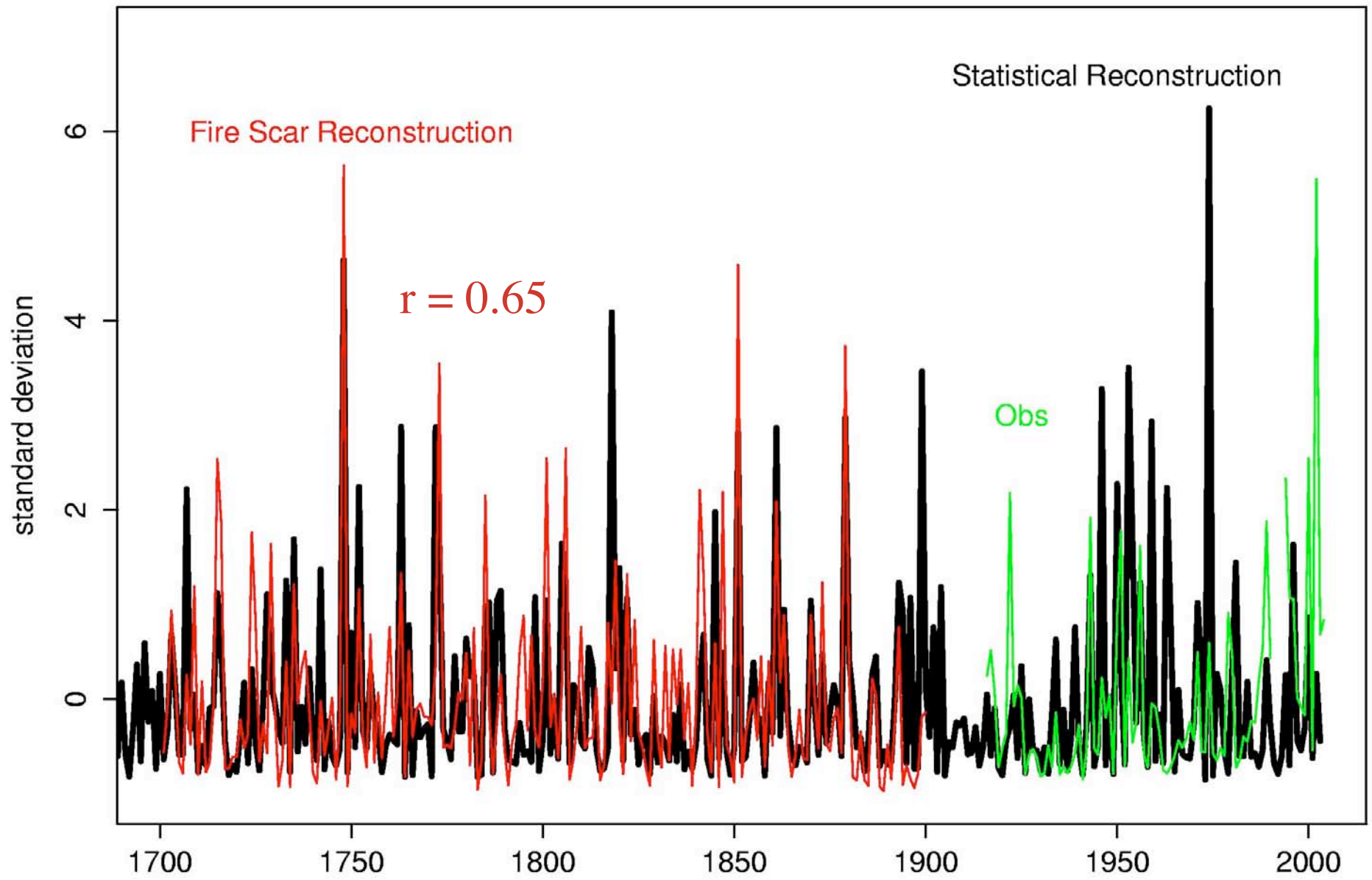
Large Fire Precipitation Composites - CNF



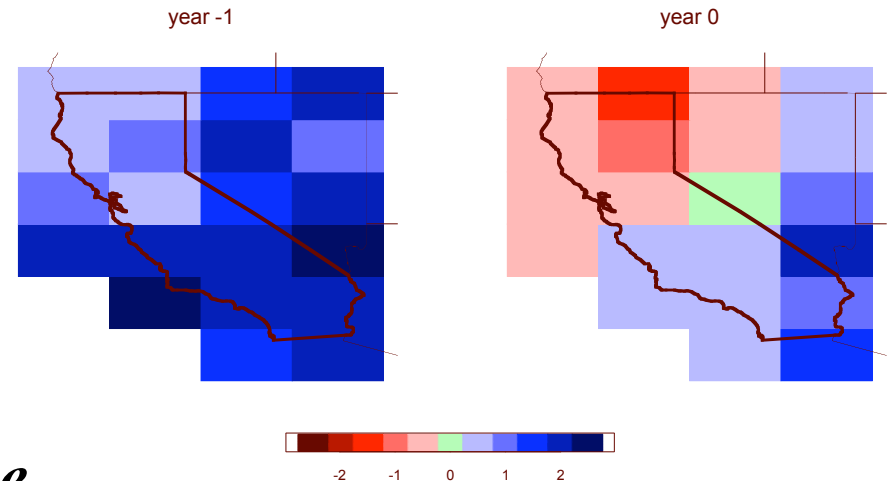
Region 1 Large Fire Frequency vs MAMJJA T



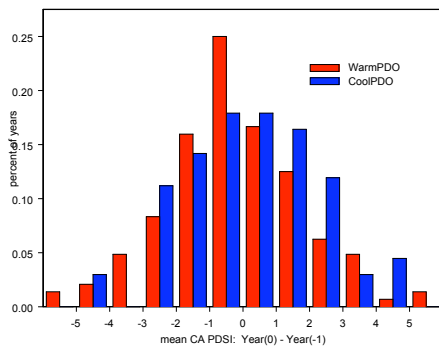
Southwest Area Burned Reconstruction



Model Composite: PDSI anomalies for 20 largest CA fire years, 1701–1900

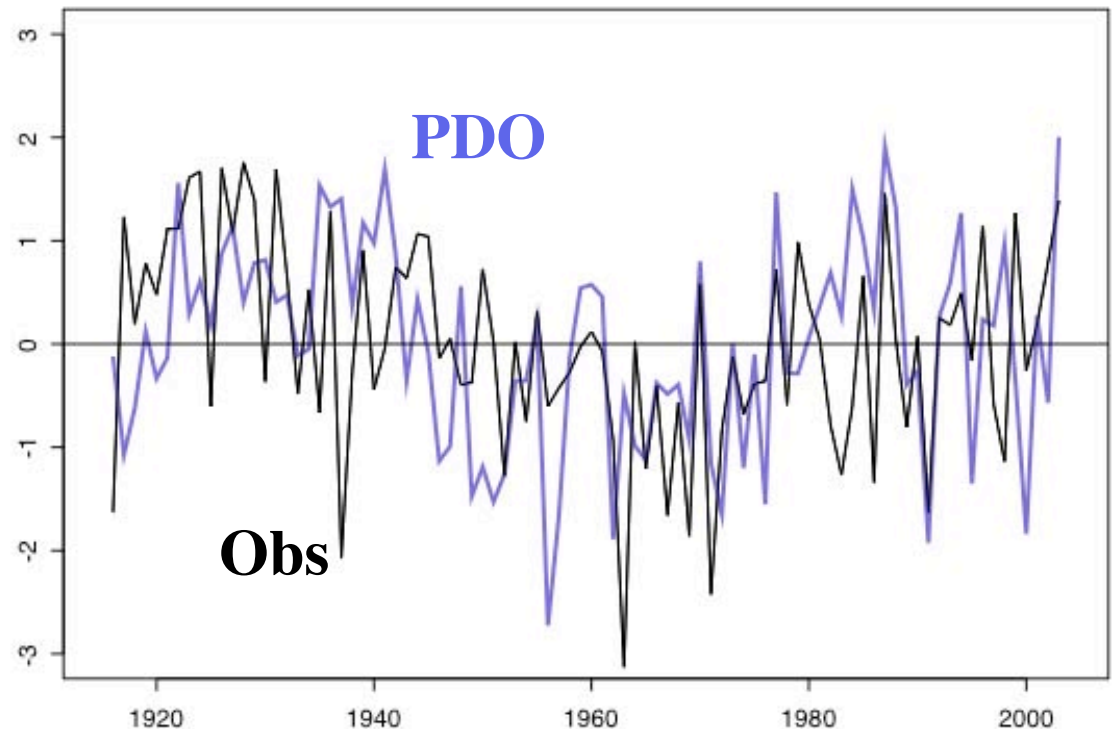


Histogram: 1st difference PDSI by PDO



*this sequencing more
likely with **warm** than
with **cool** PDO*

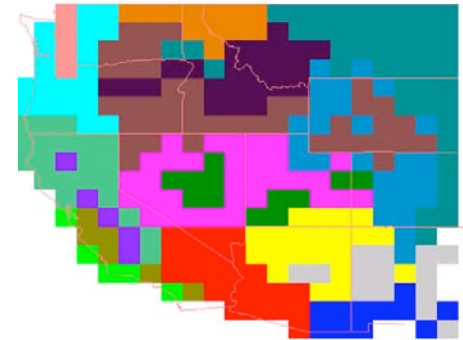
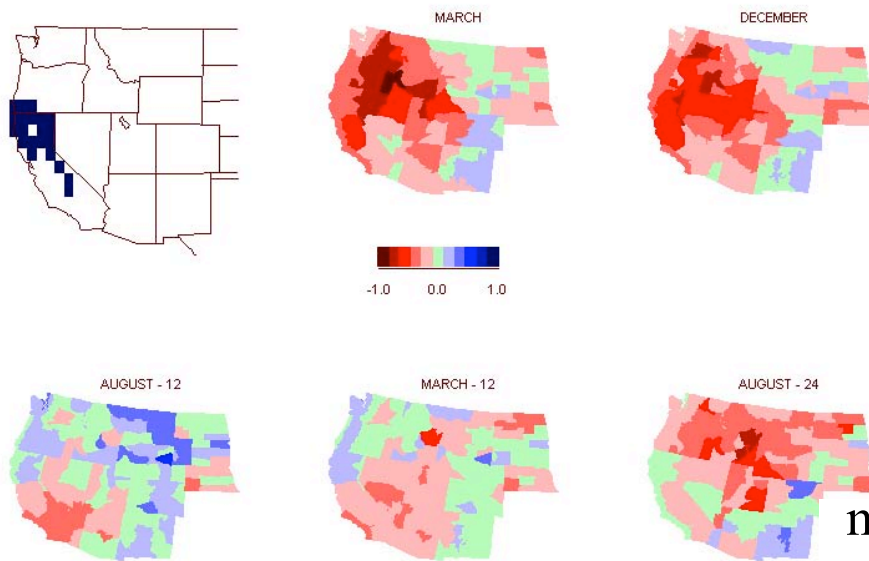
**California Observed
Annual log
Area Burned
and PDO**



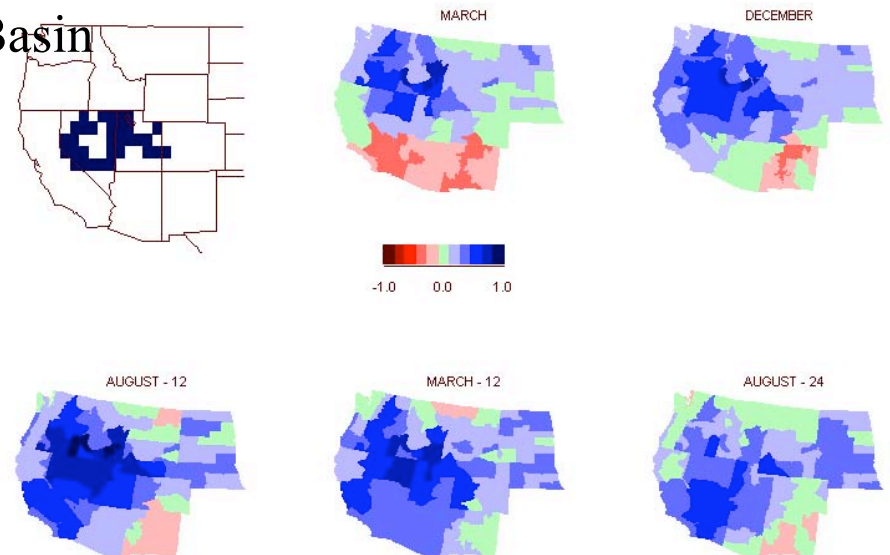
Westerling and Swetnam, in progress

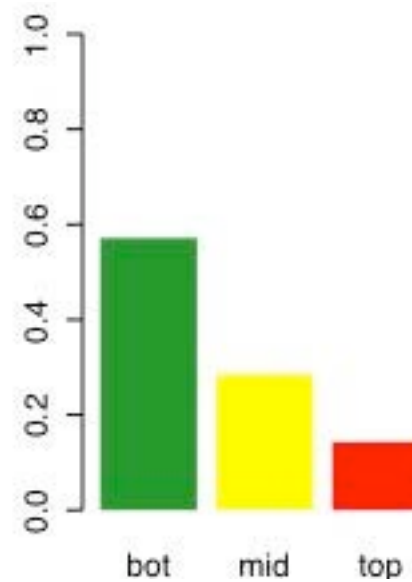
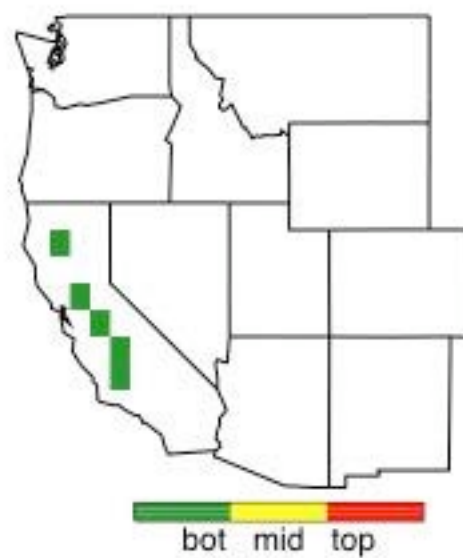
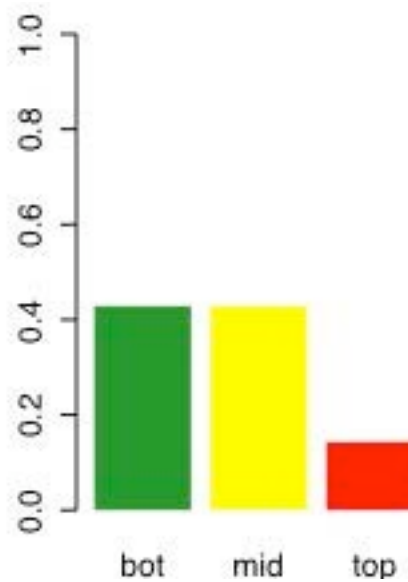
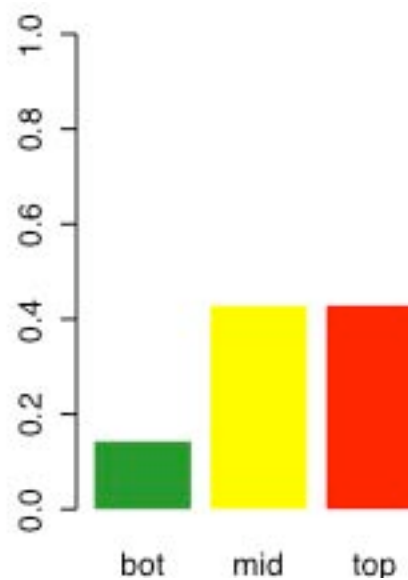
Area Burned Forecasts on Bailey's Ecosystem Provinces

model weights on PDSI for the Sierra Nevada

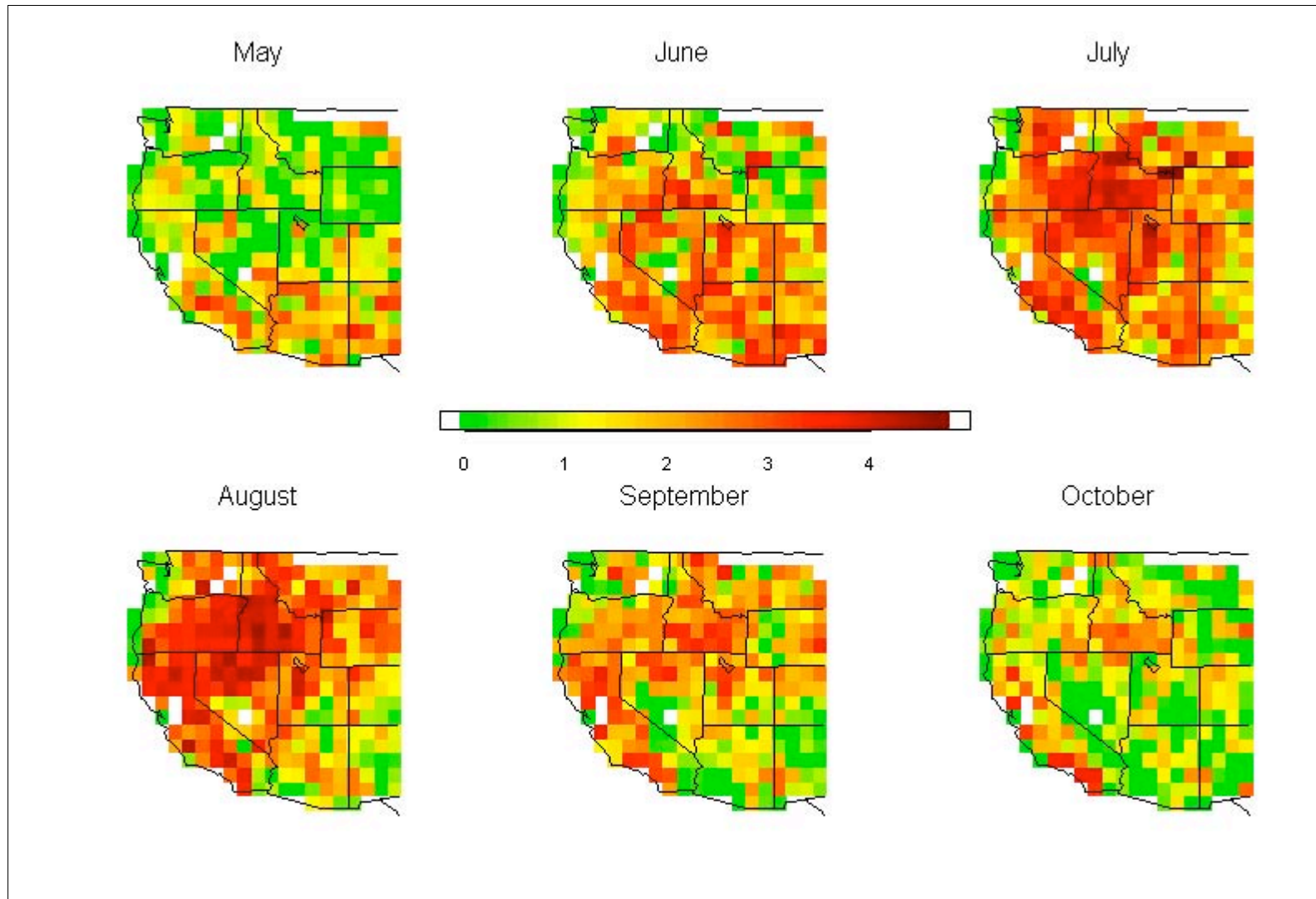


model weights on PDSI for the Great Basin



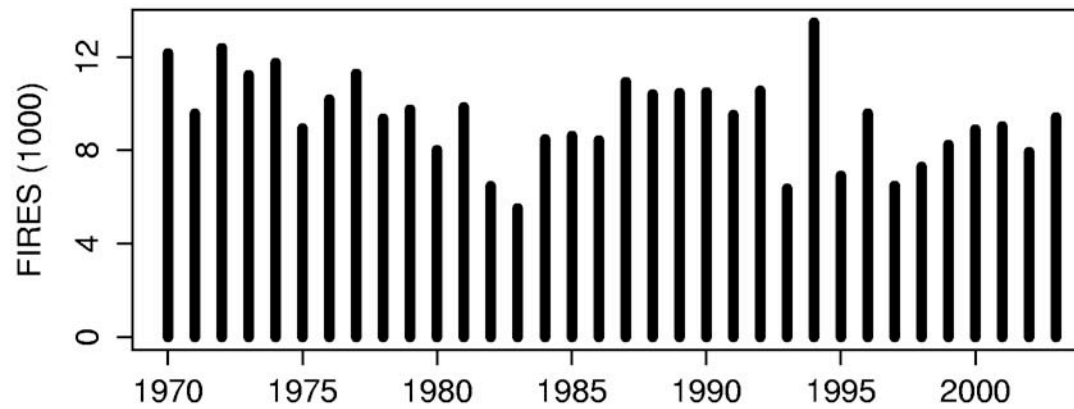


\log_{10} acres burned by month, 1 degree grid

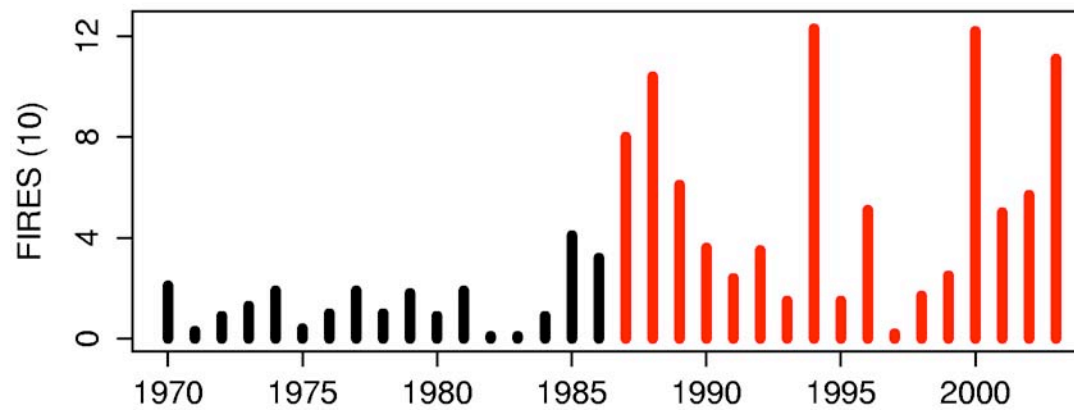


Westerling et al 2003 Bulletin of the American Meteorological Society

Western US Forests and Parks: All Reported Wildfires

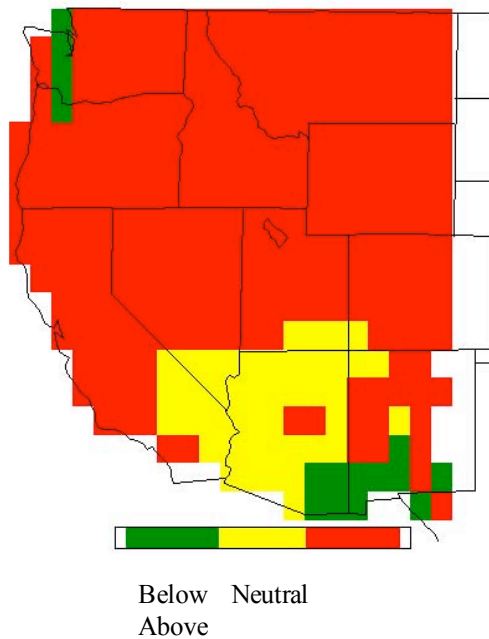


Western US Forests and Parks: Large Forest Wildfires

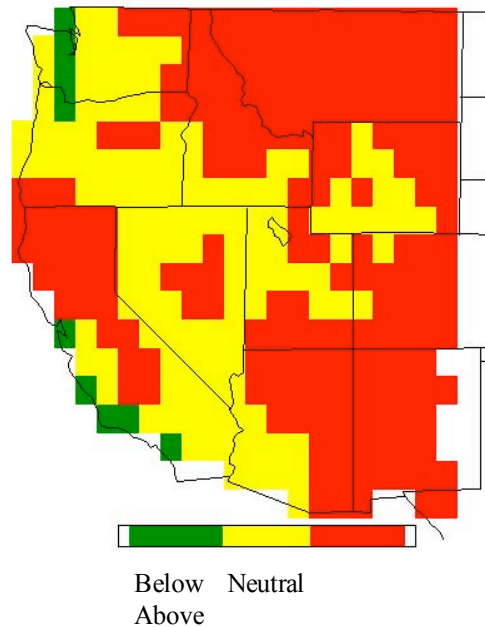


Seasonal Forecasts:

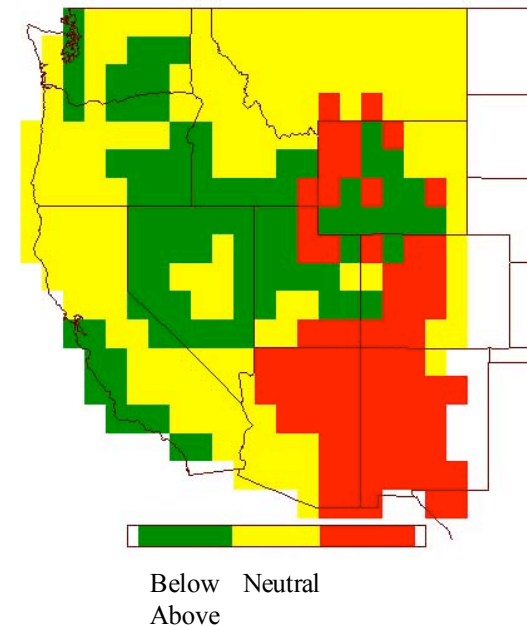
Forecast 2000
terciled area burned

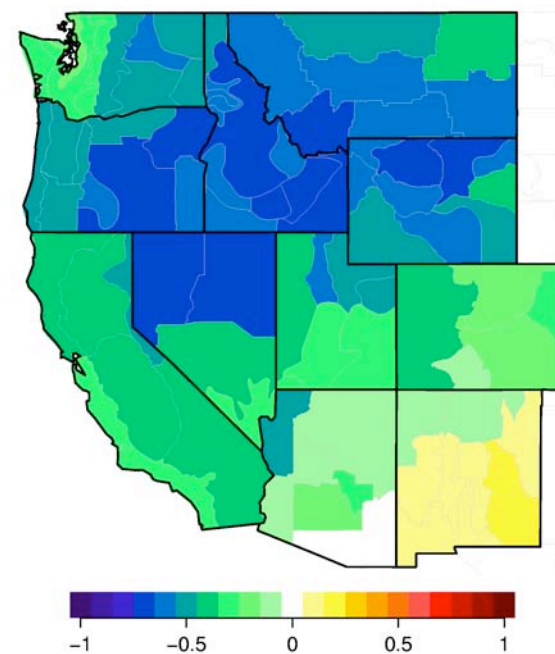
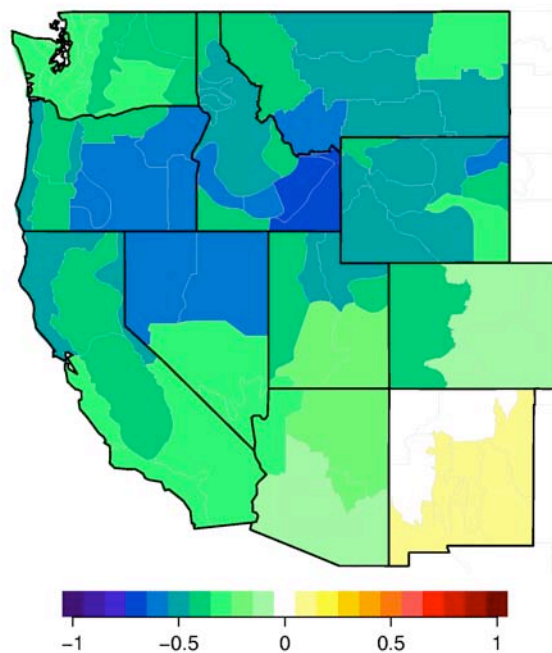
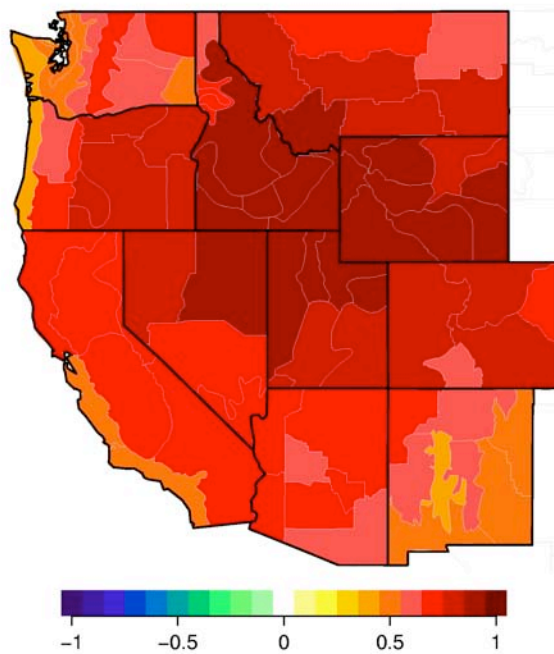


Forecast 2001
terciled area burned

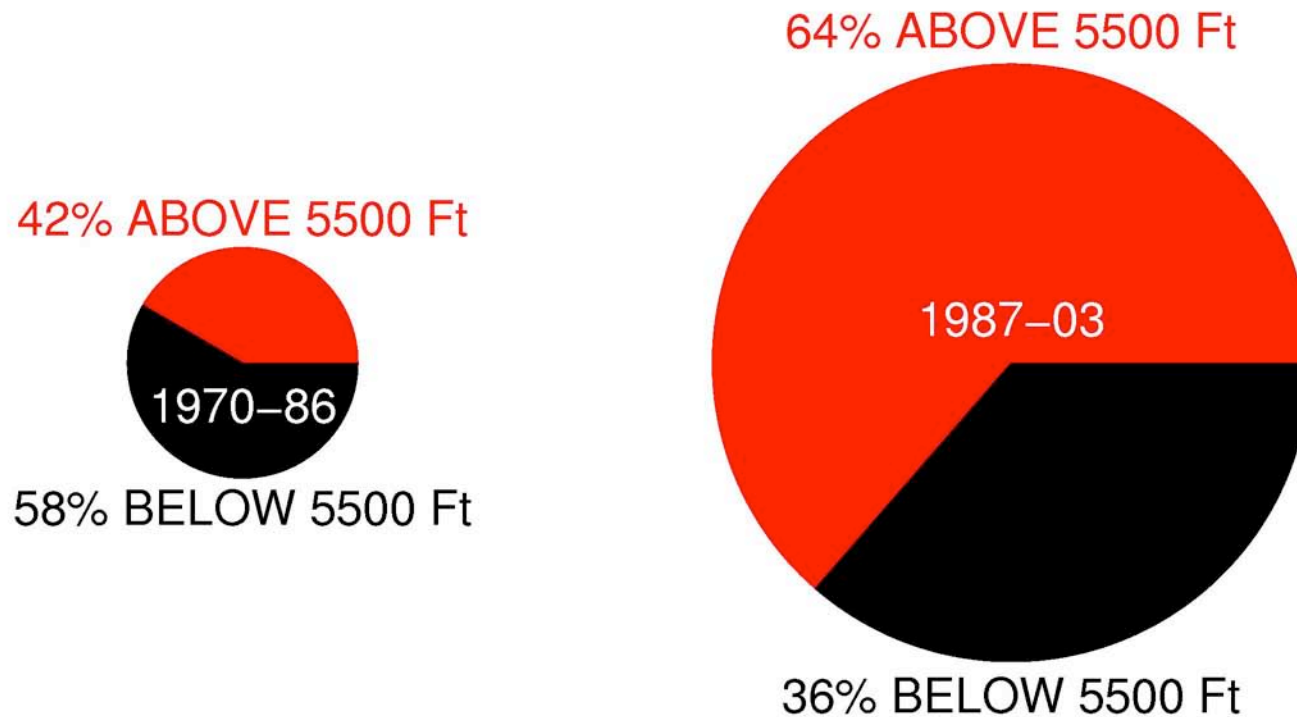


Forecast 2002
terciled area burned



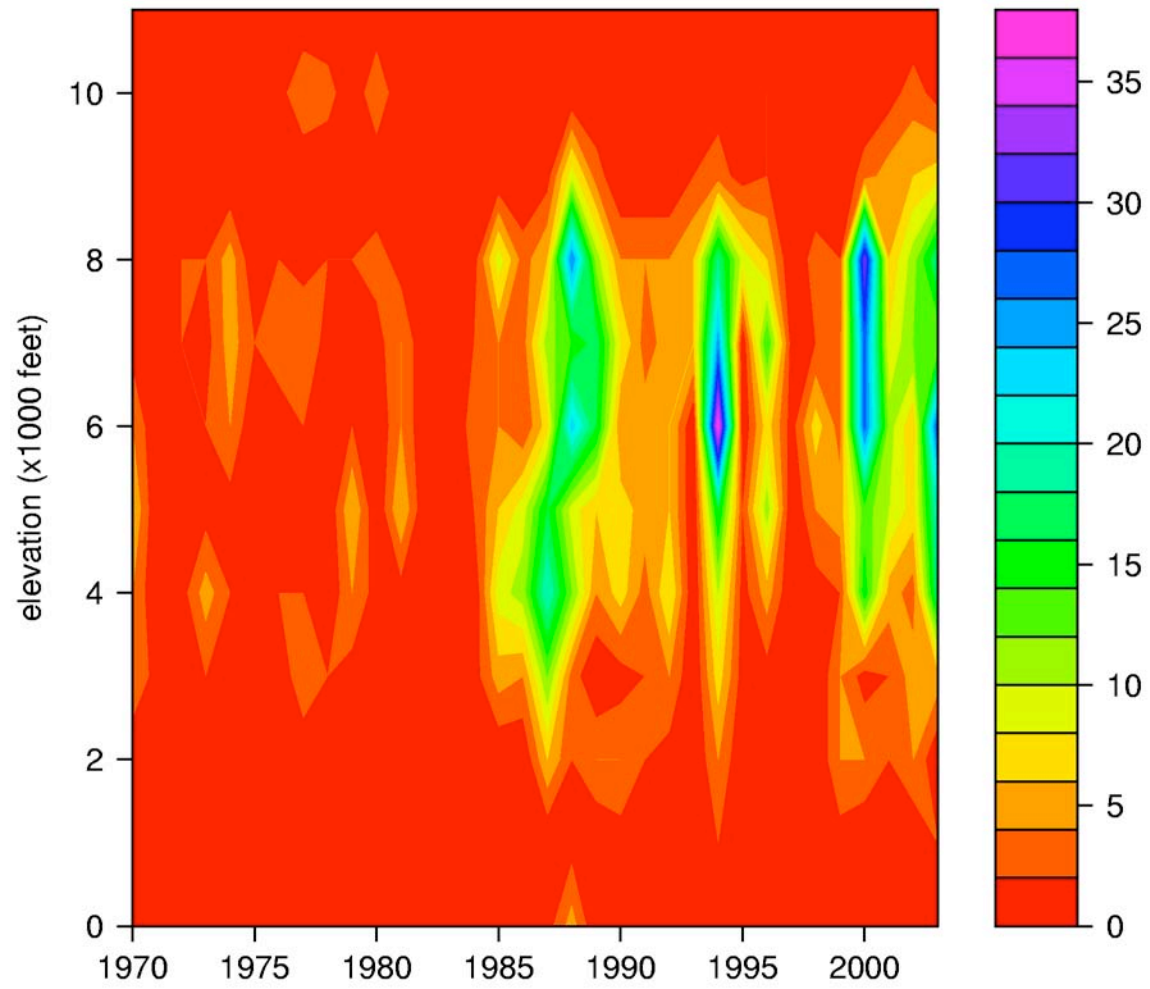


1987-03 FOREST AREA BURNED IS 6.7 TIMES 1970-86 AREA



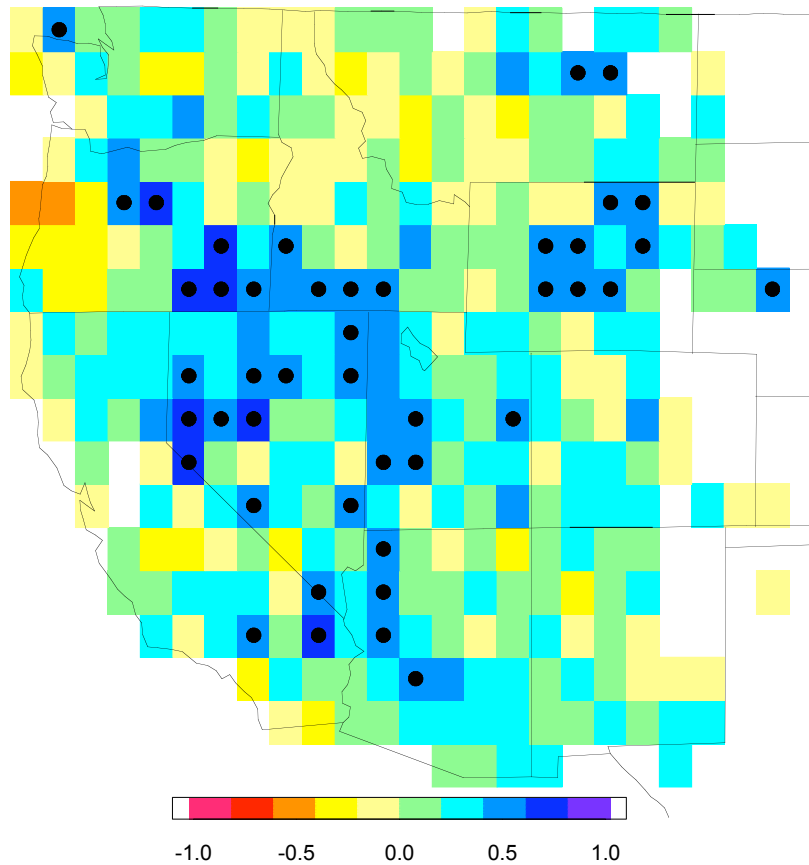
AREA BURNED IN FORESTS IN FIRES > 1000 ACRES, USF & NPS UNITS
REPORTING FROM 1970 ON

Western US Large Forest Wildfires

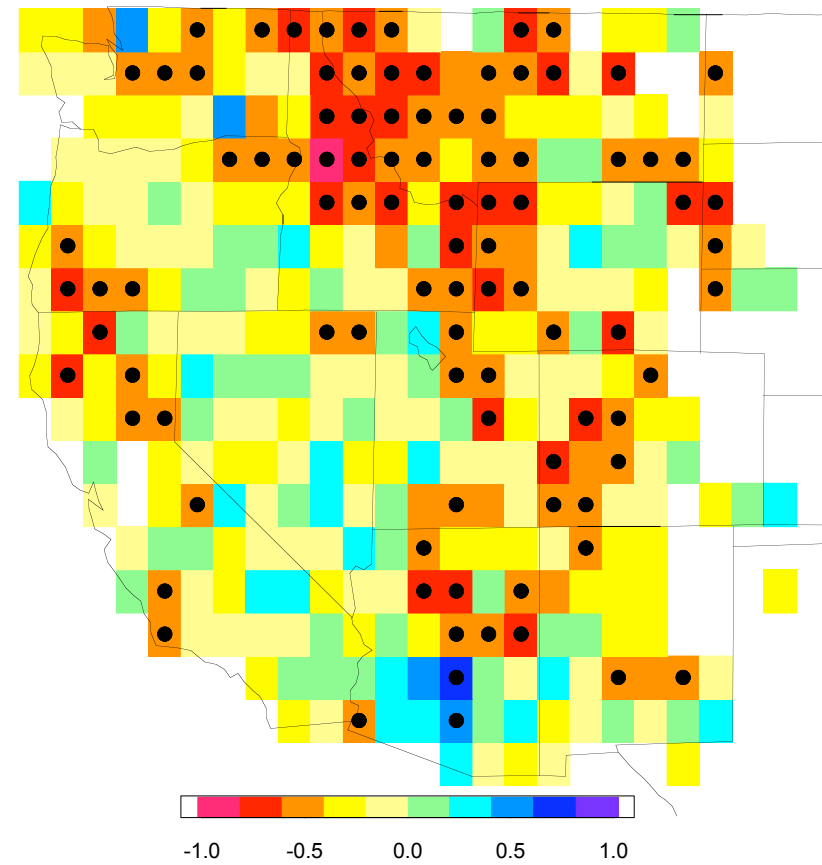


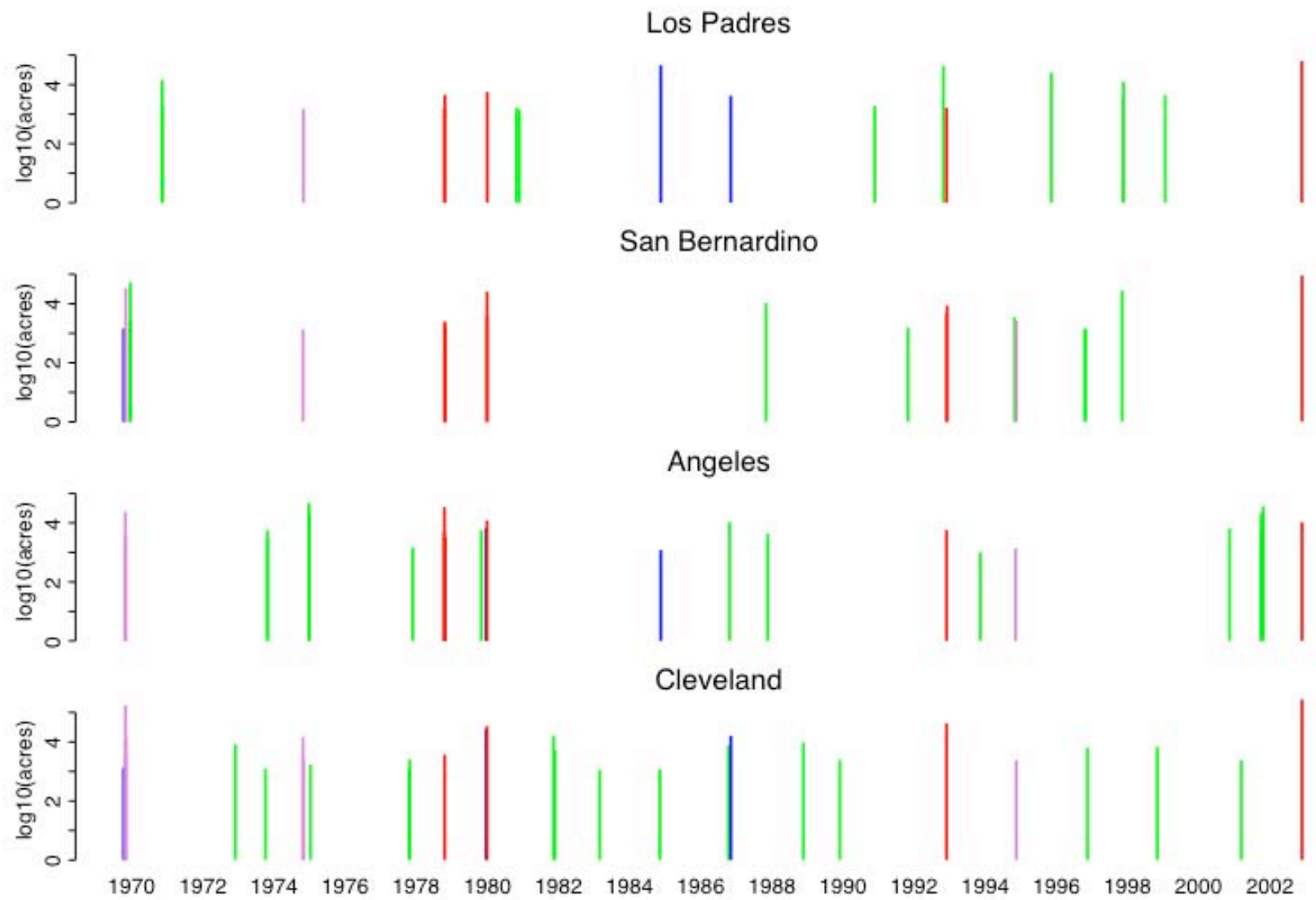
correlation, \log_{10} acres burned with:

previous year local May PDSI



current year local August PDSI





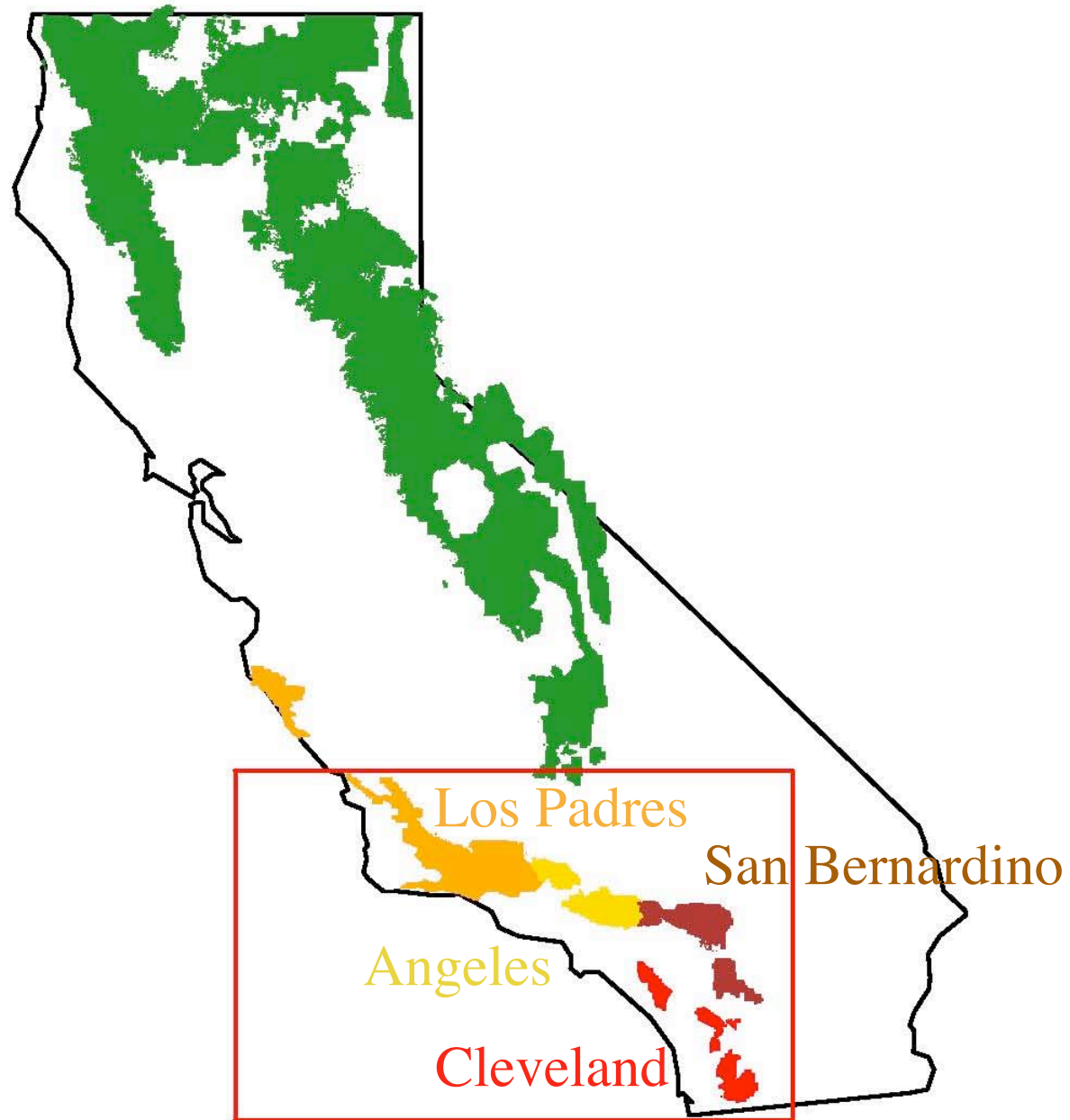
Coherence of 1000+ Acre fires in Coastal Southern California Forests over 9-Day Periods

1 Forest

2 Forests

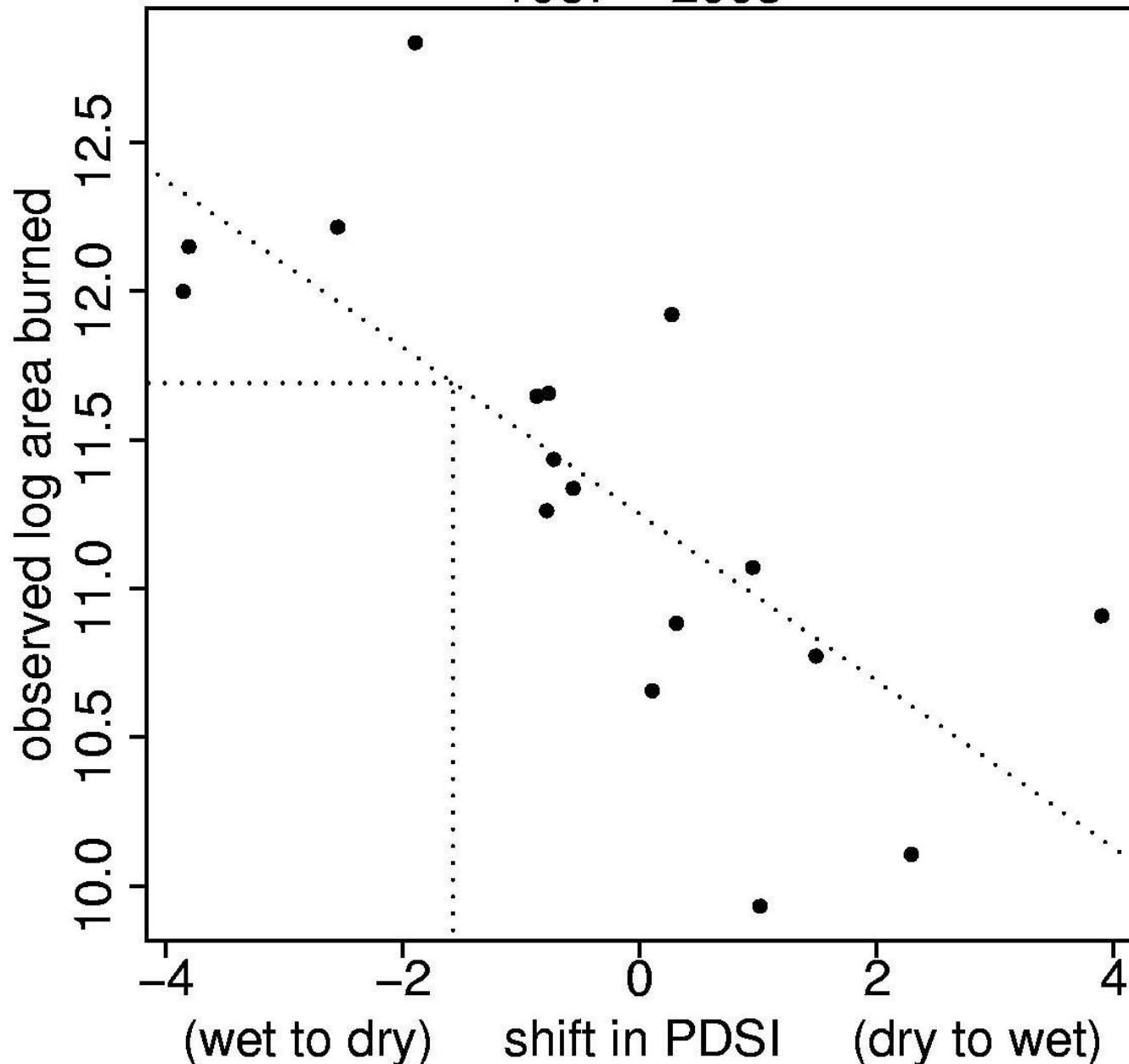
3 Forests

4 Forests



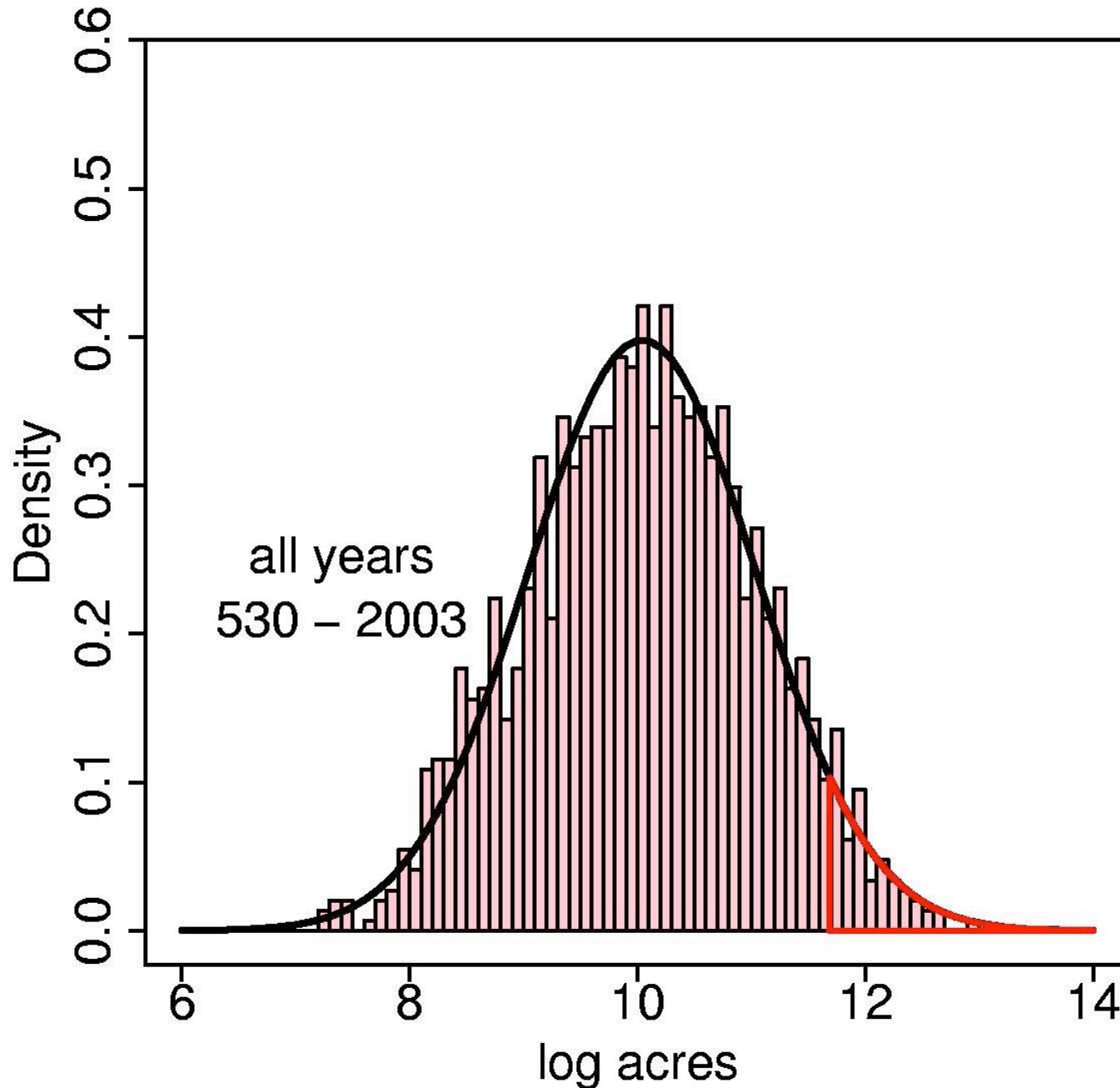
Southwest Annual Area Burned

1987 – 2003



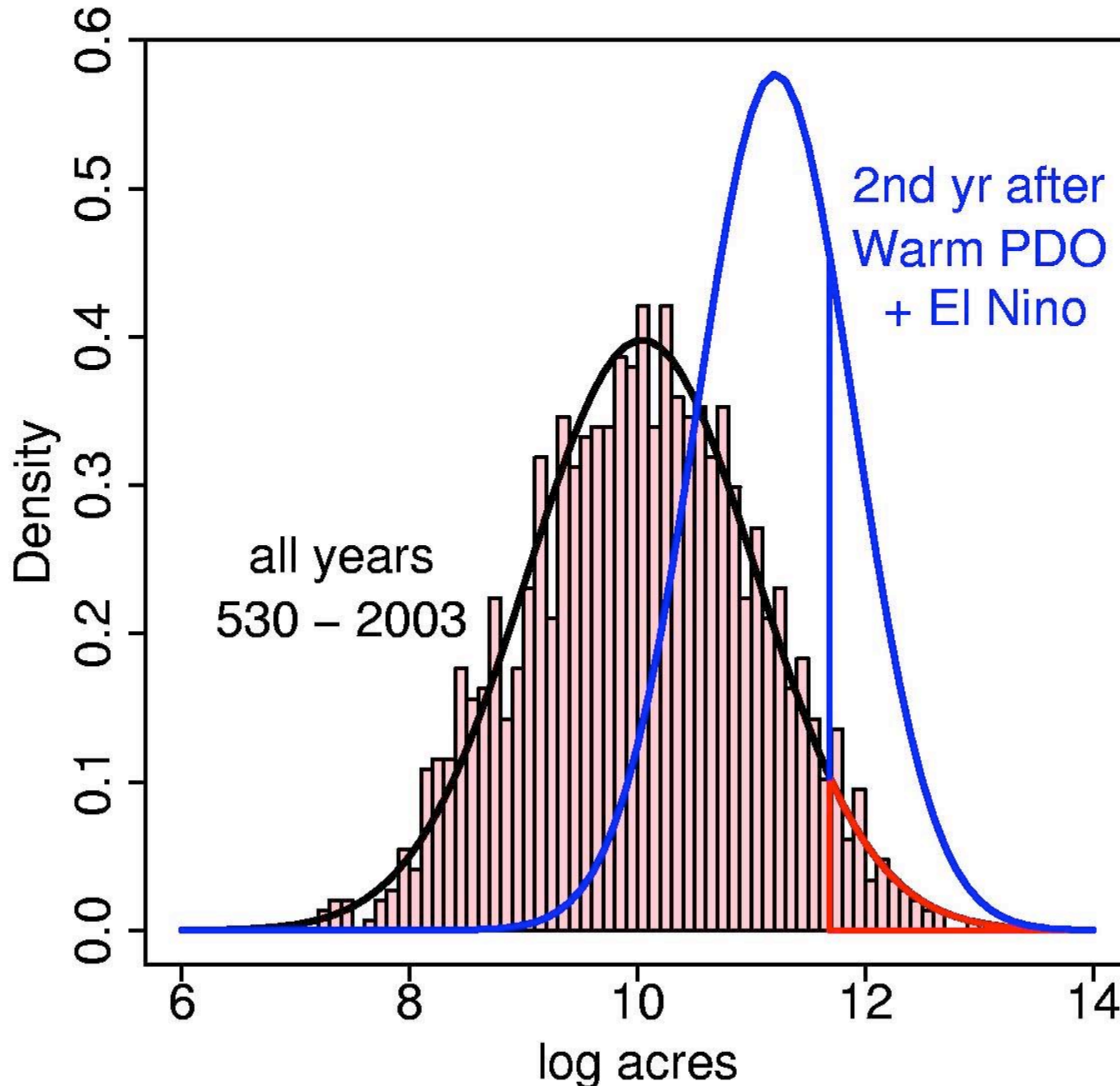
55% of variance
in observed
annual log-area
burned is
explained by
the average
shift in AZNM
PDSI from
preceding two
years

SW Reconstr. Annual Area Burned



~28% of annual
areas burned
since
1987 exceed 5%
level

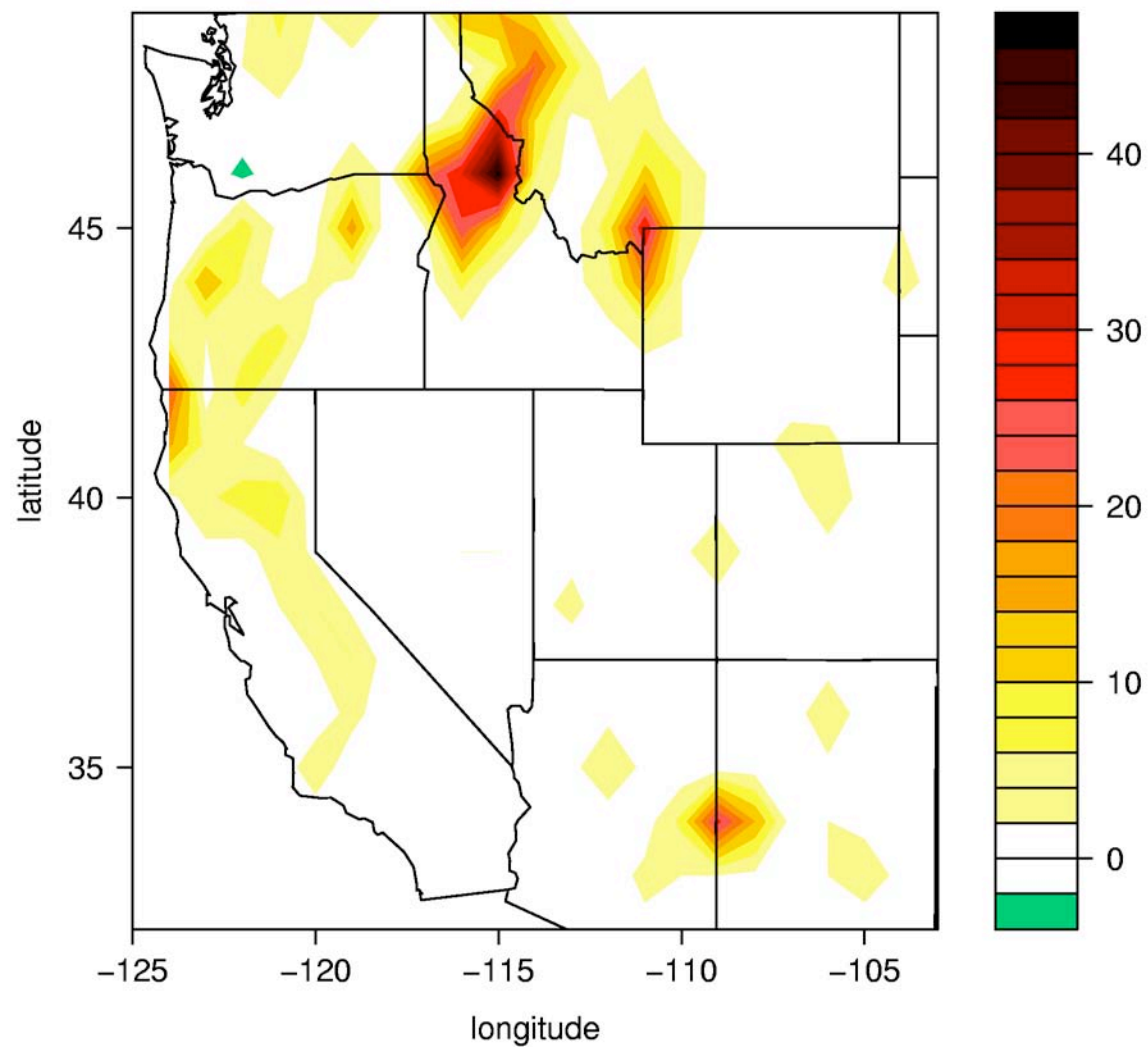
SW Reconstr. Annual Area Burned



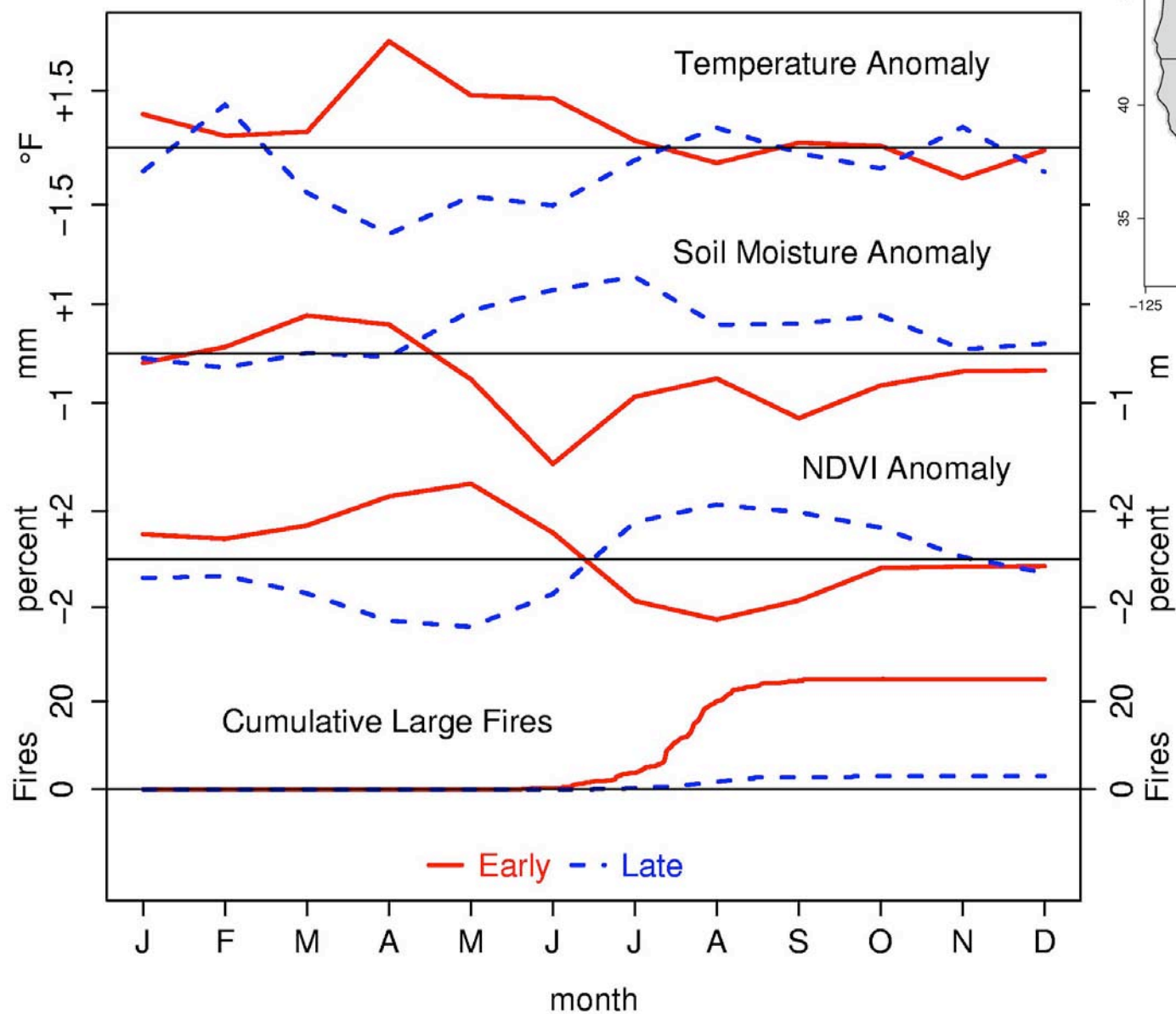
after the median
shift in PDSI
2 years after
warm PDO +
El Nino event:
5% --> 24%

~28% of annual
areas burned
since
1987 exceed 5%
level

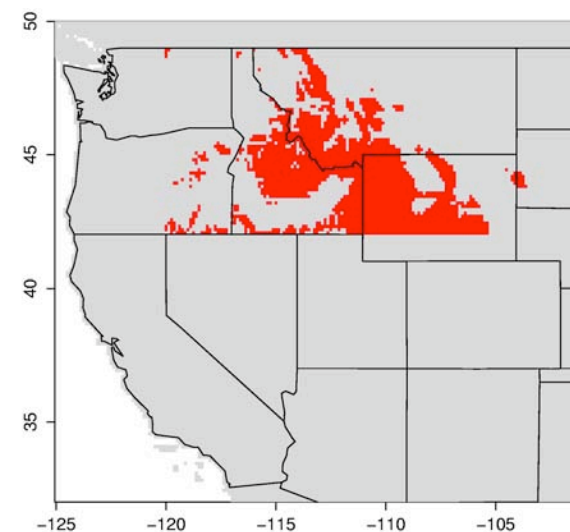
**Western US Large Forest Wildfires
Increase: 1987-03 over 1970-86**



Northern Rockies: Early versus Late Snowmelt

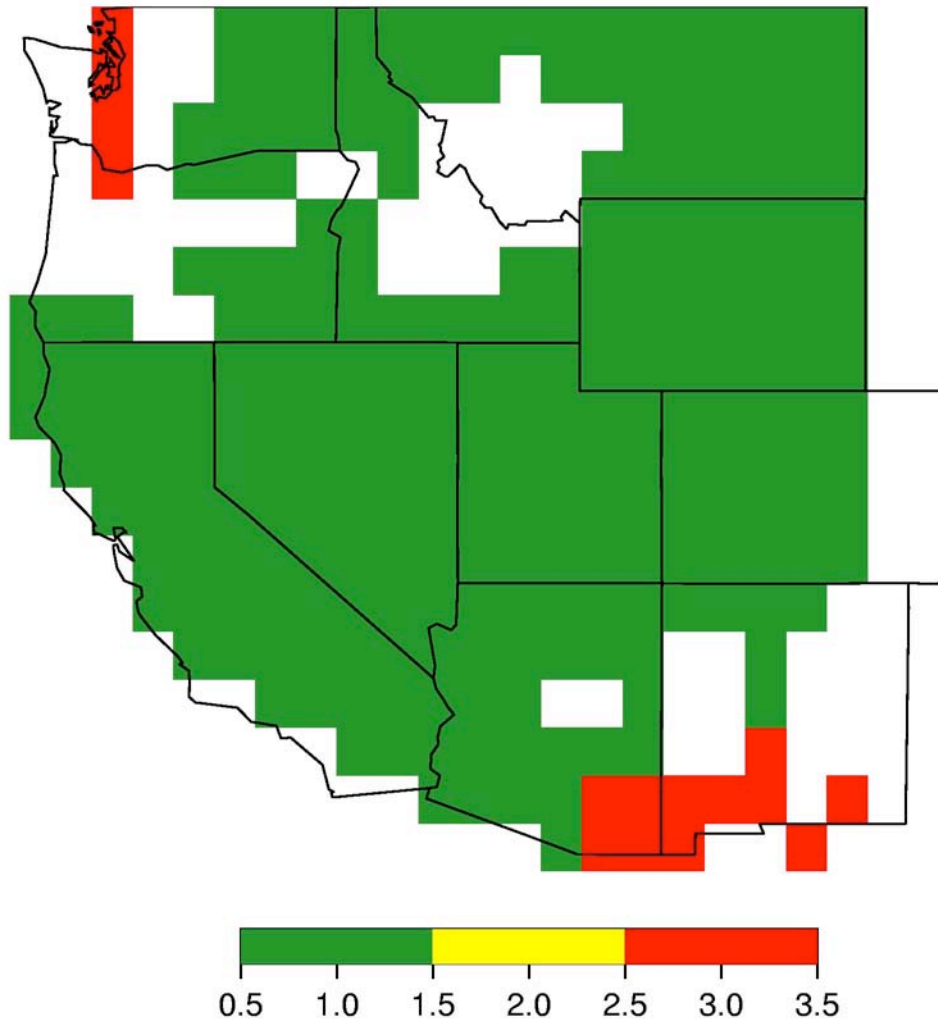


N. Central Mask - 5500'

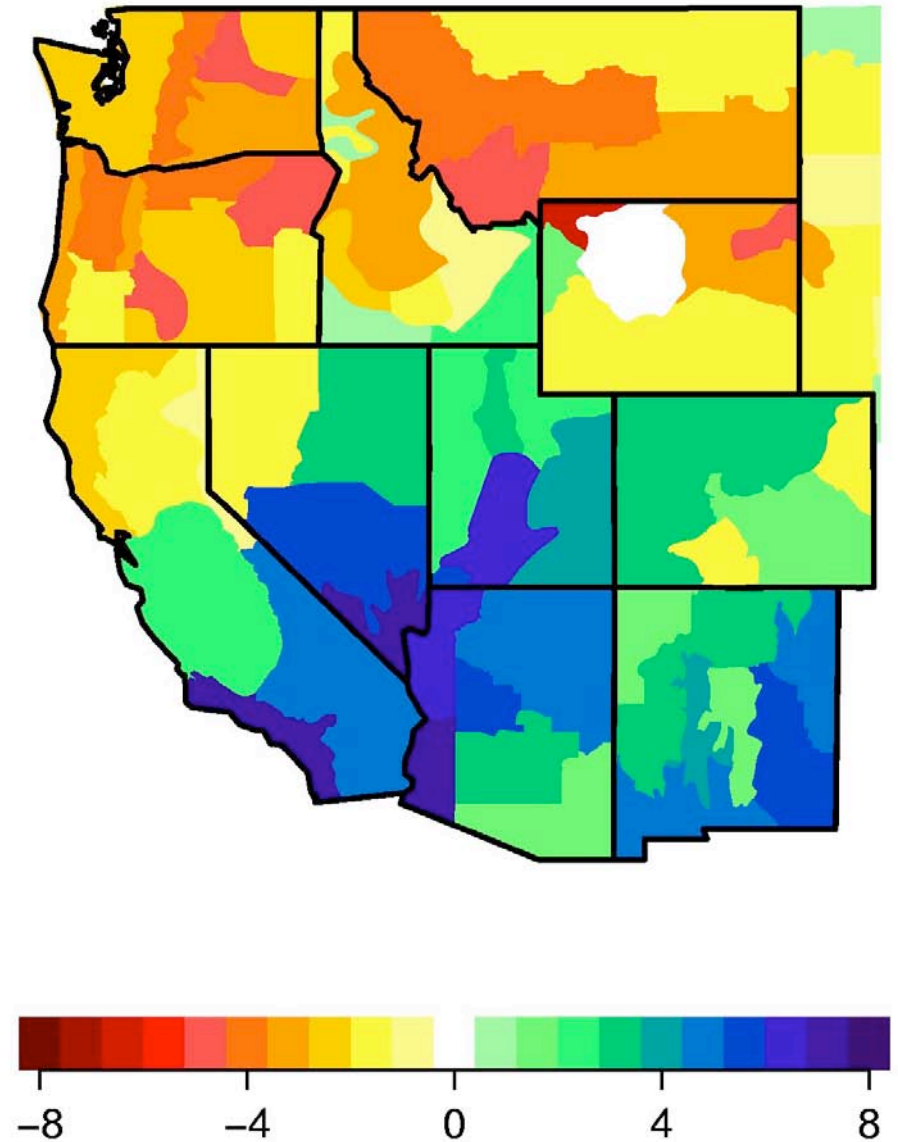


Preliminary 2005 Forecast

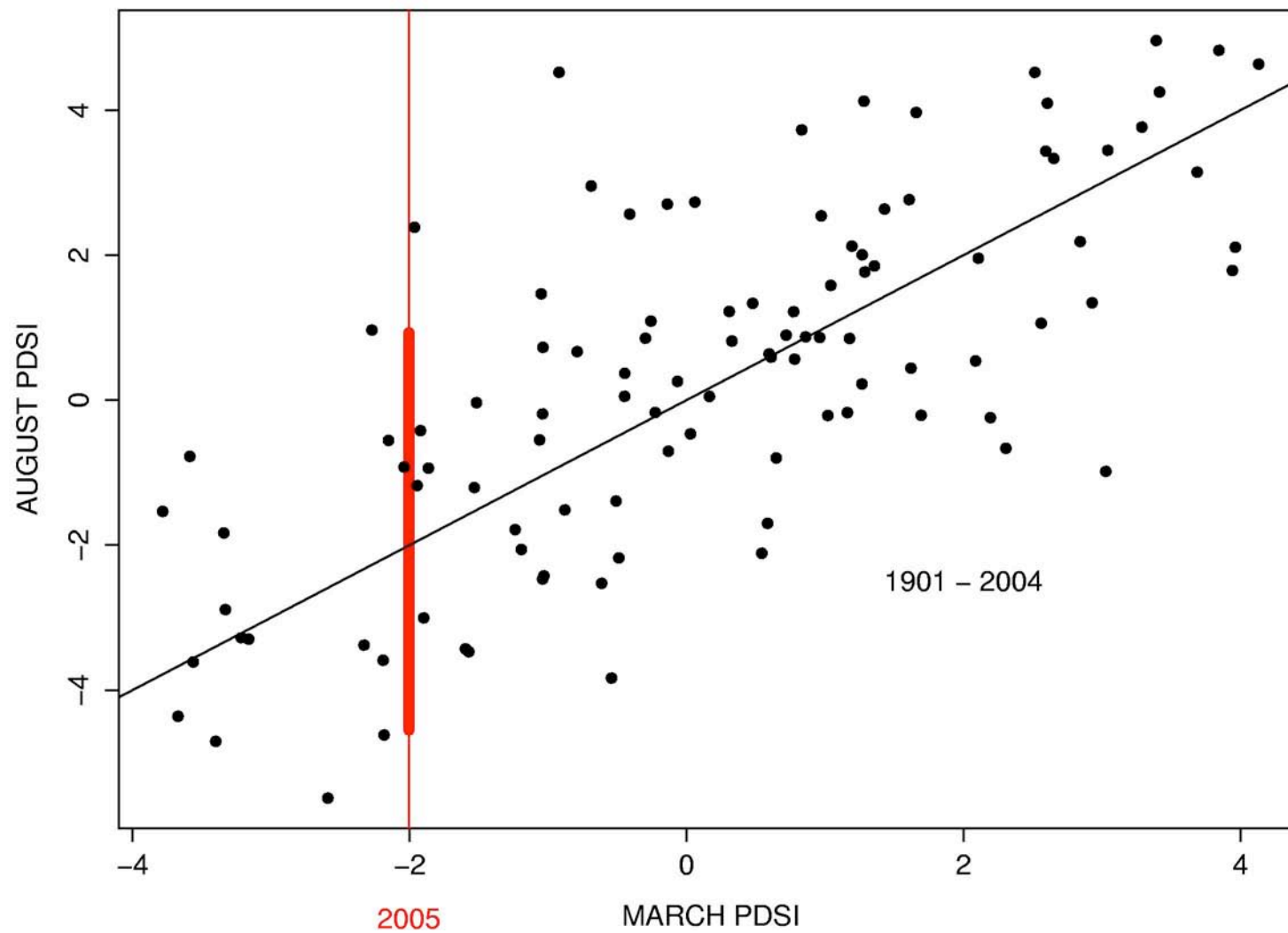
Tiled PST Forecast 2005



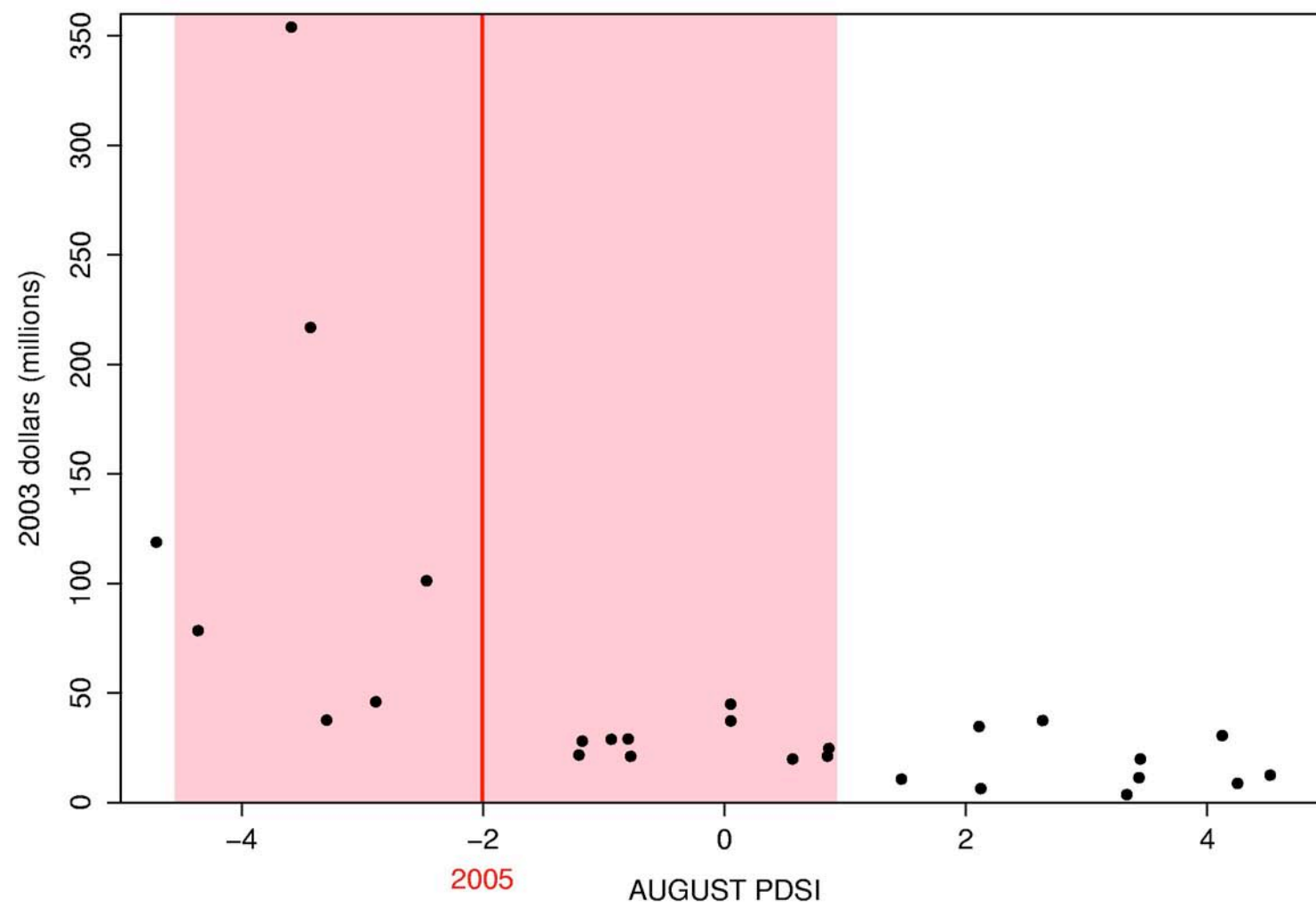
February & March 2005 PDSI



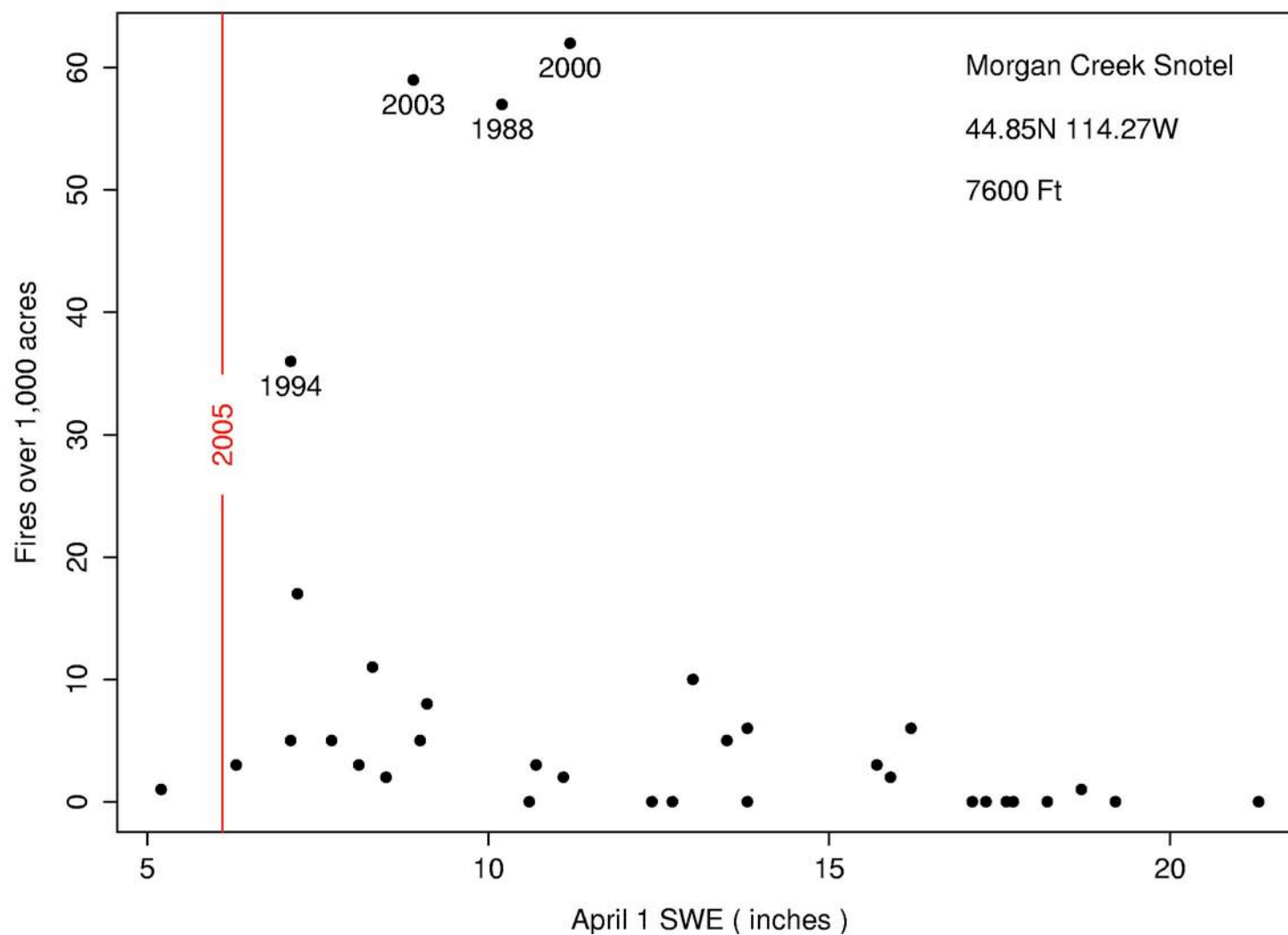
REGION 1 PDSI: MARCH -> AUGUST

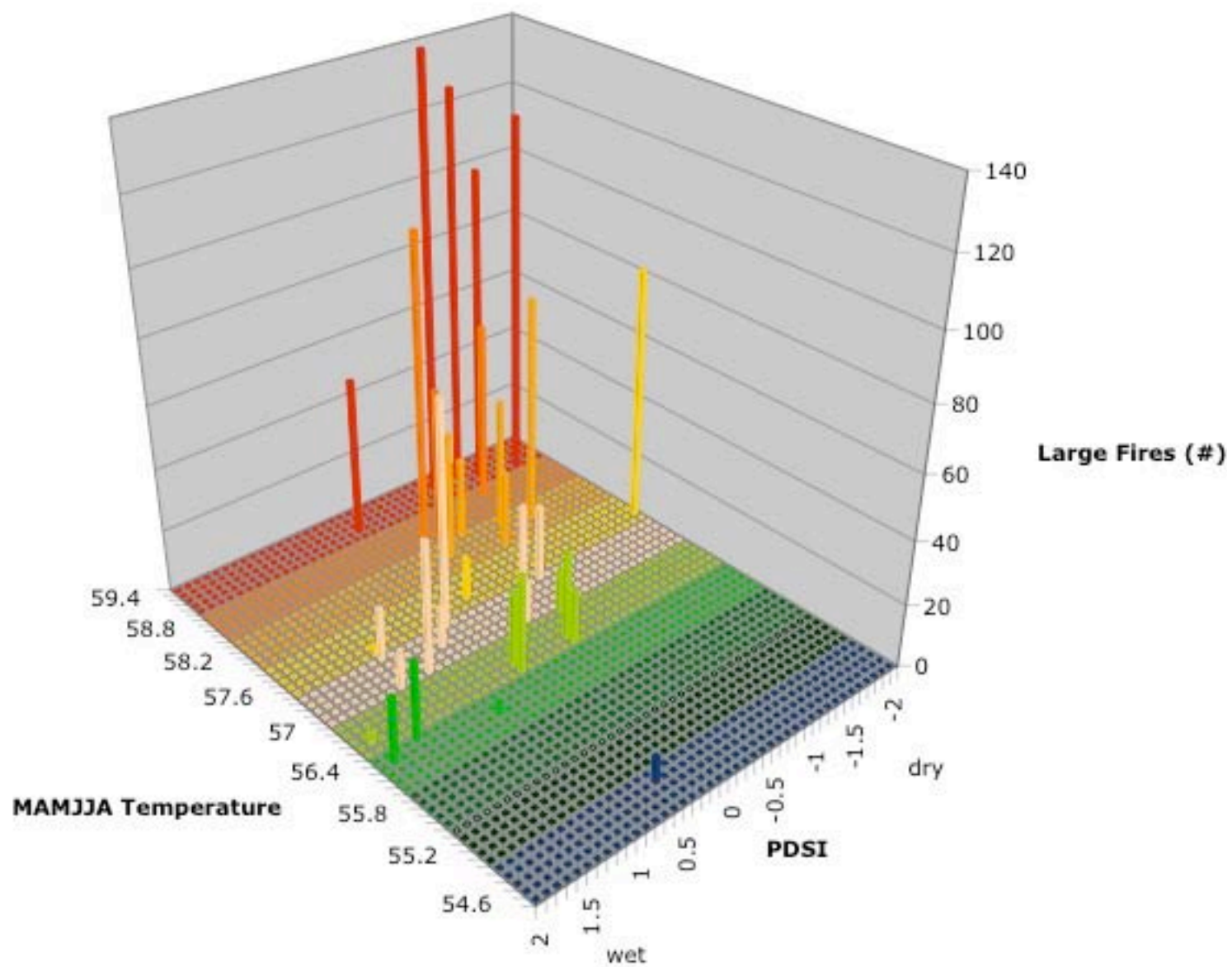


Region 1 Suppression Costs vs August PDSI

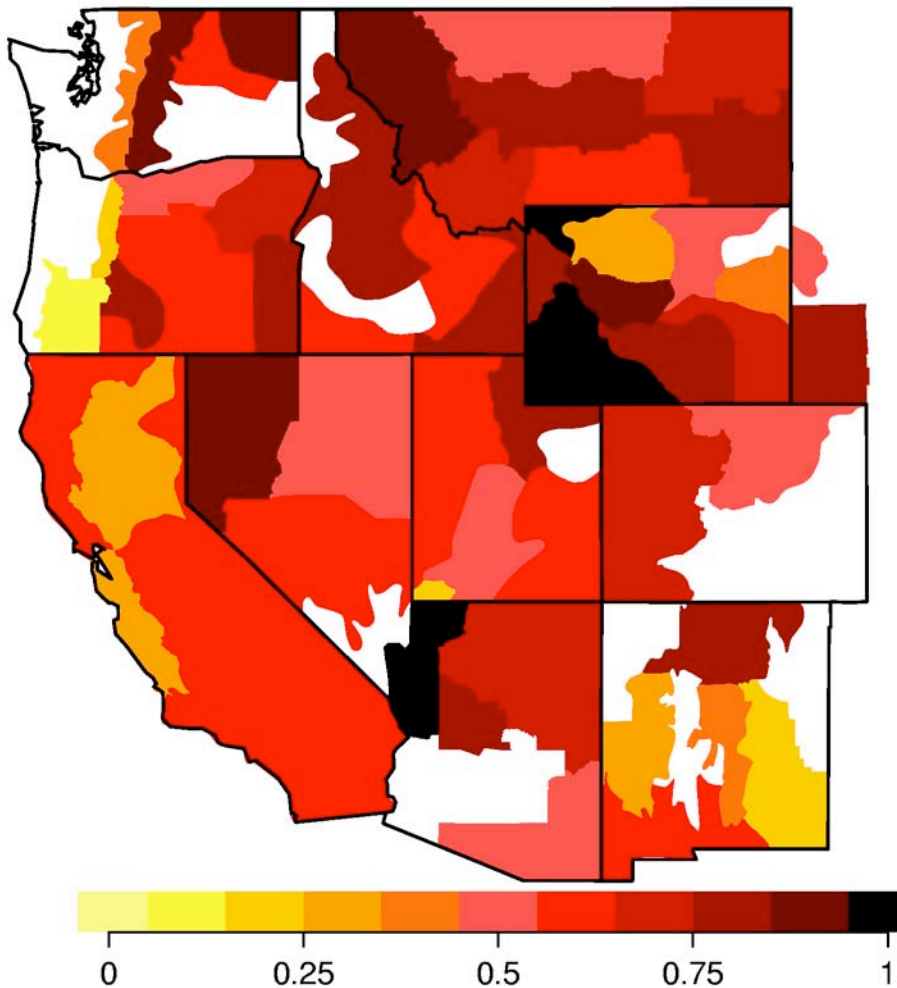


Region 1: Large Forest Fires vs April 1 SWE





Percent of Large Forest Fires
Occurring in Dry Conditions
(PDSI < -2)



Percent of Large Forest Fires
Occurring in Wet Conditions
(PDSI > +2)

